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ABSTRACT

Since its beginning, the space program has caught the attention of young people. This space science activity booklet was designed to provide information and learning activities for students in elementary grades. It contains chapters on: (1) primitive beliefs about flight; (2) early fantasies of flight; (3) the United States human spaceflight programs; (4) a history of human spaceflight activity; (5) life support systems for the astronaut; (6) food for human spaceflight; (7) clothing for spaceflight and activity; (8) waste management systems; (9) a human space flight log; and (10) additional activities and pictures. Also included is a bibliography of books, other publications and films, and the answers to the three word puzzles appearing in the booklet. (TW)

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HUMAN SPACEFLIGHT

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Activities
for the
Primary Student

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FAMOUS QUOTATIONS

" There shall be wings! If the accomplishment be not for me, 'tis for some other. The spirit cannot die; and man, who shall know all and shall have wings, shall indeed be as a god."

Leonardo da Vinci (1452–1519)

"The Earth is a cradle of the mind, but we cannot live forever in a cradle.

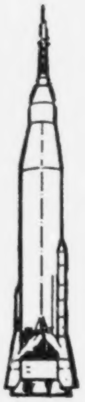
"To set foot on the soil of the asteroids, to lift by hand a rock from the Moon, to observe Mars from a distance of several tens of kilometers, to land on its satellite or even on its surface, what can be more fantastic? From the moment of using rocket devices a new great era will begin in astronomy: the epoch of the more intensive study of the firmament."

Konstantin E. Tsiolkovsky, Father of Russian Astronautics (1896)

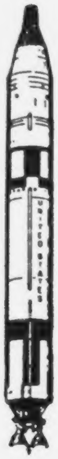
"It may be said that the development of science in the field of space flight and related research will be of great significance for the progress of human culture."

Professor Leonid Sedor, U.S.S.R.

Mercury-Redstone



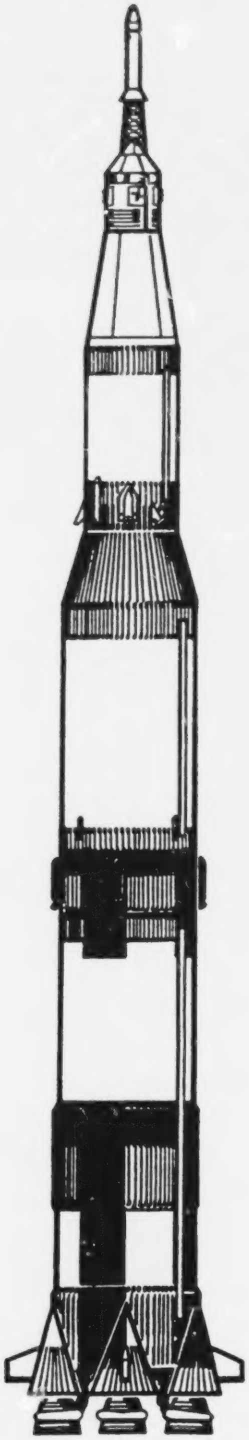
Mercury-Atlas



Gemini-Titan

USA
UNITED STATES

Saturn IB



Saturn V

HUMAN SPACEFLIGHT

CONTENTS | PAGE

PRIMITIVE BELIEFS 1
OUR FANTASY OF FLIGHT 3
UNITED STATES HUMAN SPACEFLIGHT PROGRAMS 5
HISTORY OF HUMAN SPACEFLIGHT ACTIVITY 15
LIFE SUPPORT SYSTEMS FOR THE ASTRONAUT 17
FOOD FOR HUMAN SPACEFLIGHT 21
DRESSED FOR SPACEFLIGHT AND ACTIVITY 39
WASTE MANAGEMENT SYSTEMS AND ACTIVITY 49
HUMAN SPACE FLIGHT LOG 63
ACTIVITIES AND PICTURES 69
BIBLIOGRAPHY i
WORD PUZZLE ANSWERS iv

COMMENT TO TEACHERS: Since its beginning, the space program has caught the attention of young people. Therefore, space science has created high interest and continues to prod the imagination of interested students.

This activity packet has been designed to enhance the curriculum and challenge the abilities of gifted students. Duplication of the material for classroom use is encouraged.

Written by: John W. Hartsfield
Aerospace Education Specialist
NASA Lewis Research Center
Cleveland, Ohio 44135

Kendra J. Hartsfield
Student
Lanphier High School
Springfield, Illinois

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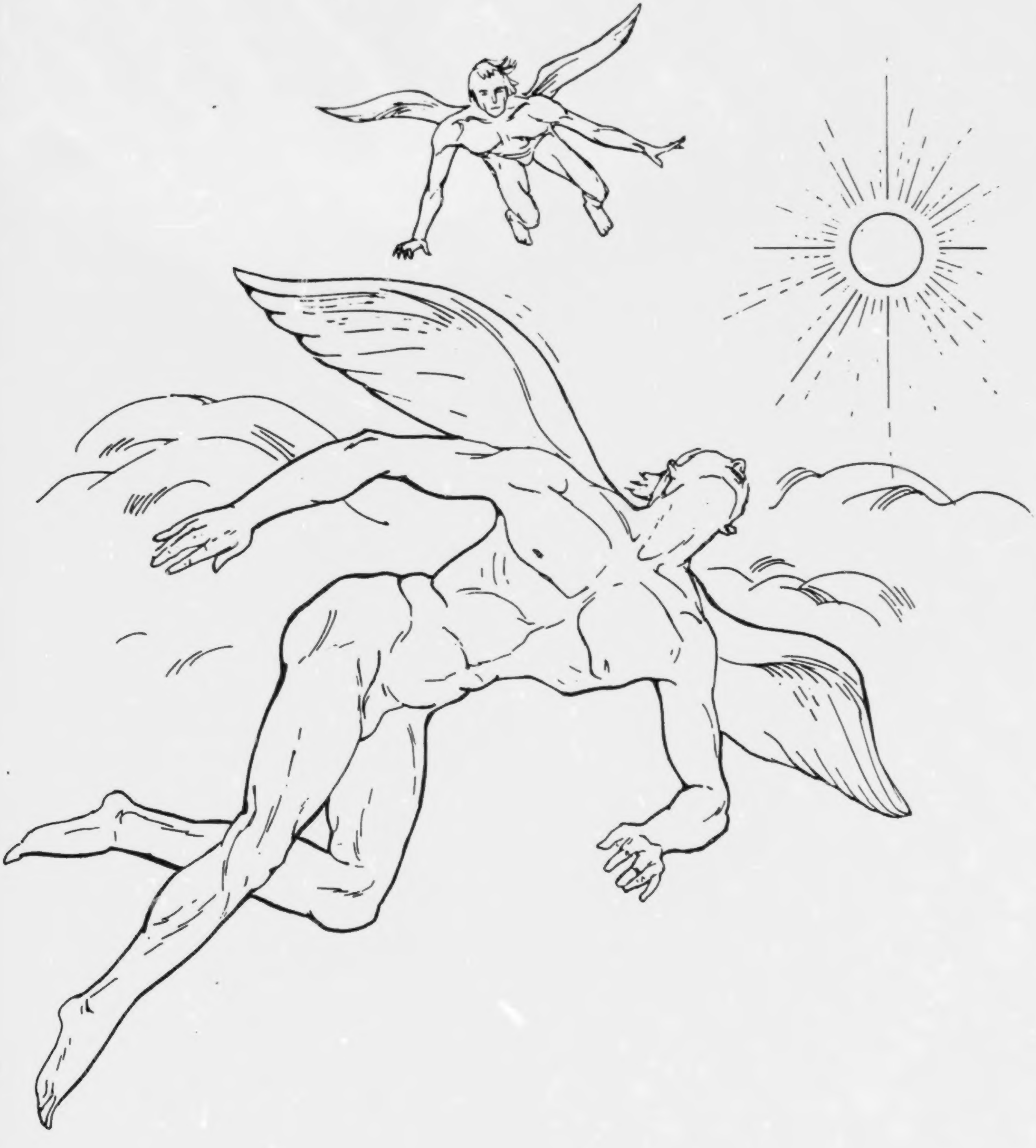


PRIMITIVE BELIEFS

Today most informed persons realize that we live on a rotating ball-sized mass called the "earth" which, in turn, is in orbit around a modest-sized star called our "sun". There have been many different beliefs about our universe. Some said it was flat. Others thought the earth was the center of the universe and everything rotated around it.

The domain of space above the surface of the earth has always been a source of wonderment for people. For several tens of thousands of years, the life of primitive people was a struggle to hunt for food and shelter to stay alive and to raise offspring. They must have wondered about the physical hardships imposed by nature -- the storms, rain, drought, heat and cold. The radiations of the sun and the falling of rain made them look to the heavens for explanations of where the mysterious and unexplainable forces of nature originated. To the Egyptians, the Milky Way was the "heavenly Nile".

Important gods lived above in the heavens, and when they died, many people believed they went to a remote "heaven" or after-life beyond the earth. Preoccupation with space is thus as old as history itself. But early people never really understood the regions beyond earth as we do today.

The science of astronomy originated in Babylon and Egypt. With this science men and women began to understand their universe better. The Babylonian priests acquired a remarkable knowledge about the periods of the sun, moon and the planets. They developed calendars and sun clocks. It is said that the Egyptians recorded sighting the planet Venus 1500 years before the time of Christ.

In Greece, astronomy grew from Pythagoras (475 B.C.), who founded geometry. His followers first suggested the earth was round or really a sphere.

The great alteration of our concept of the solar system was authored by a brilliant and timid Polish mathematical astronomer, Nicholas Copernicus (1473-1543). Copernicus believed that the earth orbited around the sun and that the sun, rather than the earth, was truly the center of the solar system.

With the discovery of the telescope by Galileo people could for the first time get a better look at the heavens. With the telescope new planets were discovered and the known universe really began to enlarge.

While the telescope enabled people to look at the heavens in greater detail, they also began to dream of traveling to distant places in the universe.

OUR FANTASY OF FLIGHT

One of the earliest artifacts illustrating human flight was a Babylonian seal dating from 3500 B.C. On this seal is pictured the shepherd king, Etena, flying to heaven on the back of an eagle.

In 1500 B.C. a Persian king, Kau Kaus, an astronomer, attempted to fly to heaven by means of fastening eagles to his throne.

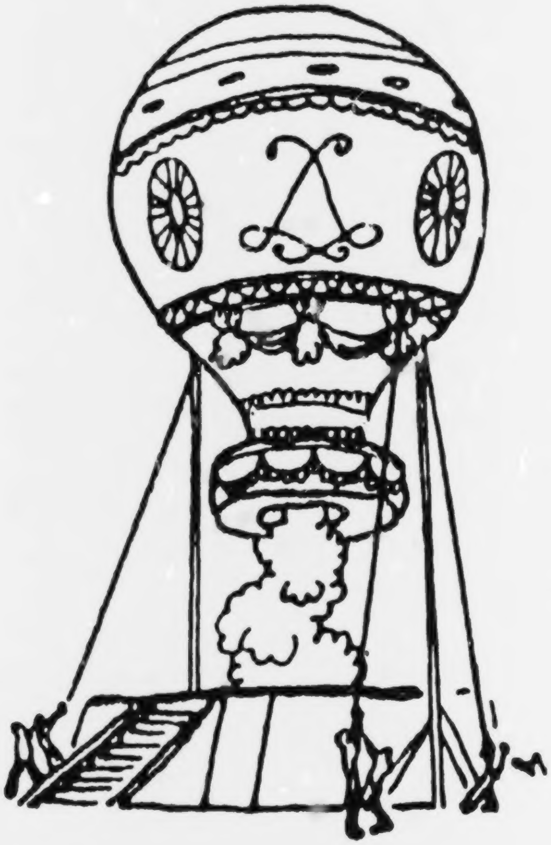
Historians tell us also about the classic myth of Icarus and Daedalus. Icarus flew too near the sun. His wax-cemented wings of bird feathers melted and he crashed to his death.

With the use of Galileo's telescope, with which he detected mountains on the moon, speculations concerning flight to the moon began to appear. The publishing in 1634 of Kepler's "Somnium" four years after his death, was the greatest science fiction classic of space flight in its day.

Francis Godwin's "Man in the Moon" (1638) dealt with lunar flight using trained wild geese which lived on the moon and migrated to the earth. Twenty-five of them were shackled to a rig so that his hero, Domingo Gonsales, could be carried along when the geese made their regular migration back to the moon.

Cyrano de Bergerac wrote a novel, "The Voyage to the Moon" (1649), telling of several attempts at lunar flight. Cyrano first tied a string of bottles filled with dew around himself, so when the heat of the sun attracted the dew (evaporation), he would be lifted up to the moon.

The idea of a lighter-than-air ship was proposed by Francesco Lana Tarzi in 1670. It was a design which animated thought leading to the invention of the balloon, the first practical means of flight. The first successful balloon flight was a public demonstration on June 5, 1783, by Joseph and Etienne Montgolfier at Annonay, France.



Montgolfier Balloon (1783)

UNITED STATES HUMAN SPACEFLIGHT PROGRAMS

Manned space flight, popular in fiction, possible in theory, became fact on April 12, 1961, when the Russians launched Cosmonaut Yuri Gargarin into orbit. This was the first successful human space flight. Cosmonaut Gargarin made a 108-minute orbital flight around the earth.

The space race actually became reality in 1957 when the Russians launched the first artificial satellite called Sputnik 1. The launching of Sputnik 1 on October 4, 1957, gave the United States its final incentive to organize an agency to direct space flight. The National Aeronautics and Space Administration (NASA) was activated into existance on October 1, 1958, by Congress. With NASA to direct its efforts the U.S. race for space was on.

Both the United States and Russia sent non-human passengers into space before allowing the launching of men. On November 3, 1957, Russia launched Sputnik 2, containing a dog called Laika. In January of 1961 NASA launched chimpanzees "Baker" and "Abel" into sub-orbital flight. These flights proved that a living creature could travel into space and be returned safely to earth.

The first United States manned space program was called Mercury. The program was named after the famous winged messenger of the gods.

The first American in space was Alan B. Shepard, with a 15 minute, 22 second suborbital flight on May 5, 1961. There was one more suborbital flight, the following July 21, by Virgil I. Grissom. Twenty days after Shepard's flight, President John F. Kennedy announced the lunar landing program (Apollo) as a national goal to be accomplished during that decade (before 1970).

The objectives of the Mercury program were: to orbit a manned spacecraft around the earth; to investigate our ability to function in space; and to recover both man and spacecraft safely.

On February 20, 1962, the objectives of Project Mercury were achieved when Astronaut John H. Glenn, Jr., became the first American to orbit the earth. Glenn completed three orbits of the earth and was in space for 4 hours, 55 minutes, and 23 seconds. There were three more spaceflights in the Mercury program. The Mercury project came to an end with the 34-plus hour mission of Gordon Cooper in May, 1963, on Mercury 9.

The next human spaceflight program was called Gemini (twins). This two-man spacecraft program was named after the third constellation of the Zodiac with its twin stars, Castor and Pollux.

The major objectives of this program were: to subject men and equipment to space flight up to two weeks in duration; to rendezvous and dock with other orbiting vehicles and to maneuver the docked combination by using the target vehicle's propulsion system; and to perfect methods of re-entering the atmosphere and landing at a preselected point on land.

All of the objectives in this program were met except the landing on land. This was cancelled in 1964 when development problems began to impact the programs.

The first Gemini flight occured on March 23, 1965, with Astronauts Virgil Grissom and John Young aboard. They made three orbits of the earth. The Gemini 4 mission on June 3, 1965, saw Astronaut Ed White become the first American to walk in space. White stayed outside his spacecraft for 21 minutes. There were a total of ten flights in the Gemini program. This program ended on November 2, 1966, with the Gemini 12 flight. Astronaut Edwin "Buzz" Aldrin set a Gemini record for extravehicular (EVA) activity on this flight: five hours and thirty minutes of total EVA time.

It is important to note that during the Gemini program the Soviets were also making strides in their human space flight program. On June 16, 1963, Junior Lieutenant Valentina Tereshkova became the first woman in space.

The Apollo program was NASA's greatest achievement. This program was designed to take three astronauts to the moon and allow two of them to land on its surface.

The major objectives of the Apollo program were: to establish the technology to meet other national interests in space; to carry out a program of scientific exploration of the moon; and to develop our capability to work in the lunar environment.

The program required development of two new spacecraft, one of them capable of landing on and taking off from the moon. It also required a launch rocket that could lift almost 7.5 million pounds, a package of complex scientific experiments that could be deployed by two persons and a vehicle to extend the surface exploration.

On January 27, 1967, a fire on the launch pad in a simulation prior to flight killed Astronauts Grissom, White, and Chaffee, and brought the program to a standstill. The inquiry into the causes of this tragedy lasted two and one-half months.

However, this inquiry led to a more fireproof spacecraft. A new quick-opening hatch cover and other designs and procedural changes were made. These included greatly reducing the proportion of oxygen in the capsule so that the astronauts would breathe a mixture of approximately 60% oxygen and 40% nitrogen, rather than the former mixture that included a much higher proportion of oxygen which supports burning.

There were ten Apollo flights to the moon with six lunar landings. NASA had intended to make ten lunar landings, but a ruptured service module oxygen tank on Apollo 13 prevented it from landing on the moon. Budget cuts caused NASA to eliminate the last two planned landings.

On July 20, 1969, Apollo 11 landed on the lunar surface. Astronaut Neil Armstrong became the first human to step onto the moon.

On July 26, 1971, the Apollo 15 mission carried a battery-powered lunar vehicle which enabled the astronauts to travel a greater distance from their lunar module to collect samples. There were a total of three Lunar Rover Vehicles used on the moon. All three were left on the moon's surface.

The twelve Americans who left their footprints in the lunar dust totaled 166 man-hours of surface exploration. They traveled almost 60 miles and brought about 850 pounds of rock and soil samples back to earth. They left 60 major scientific experiments on the moon and conducted 34 more in lunar orbit.

Skylab, America's first space station, was launched without passengers on May 14, 1973.

Skylab was built from the third stage of a Saturn V rocket. The hydrogen tank on the third stage was converted into a spacious two-story accommodation for a three-man crew. The bottom section contained a wardroom, sleep compartments, and a washroom/toilet or "waste compartment". Above was the spacious workshop in which the astronauts could "swim" in a microgravity environment. The space station had about 11,700 cubic feet of room, approximately the same as a small two-bedroom house.

There was a total of three flights to Skylab. The astronauts stayed for 28 days, 59 days, and 84 days. A variety of experiments were conducted by the astronauts while on board Skylab.

Sixty-three seconds after liftoff, the heat meteoroid shield around Skylab was ripped away. One solar ray panel was lost and the other was damaged. This delayed the launch of the first crew to Skylab for 11 days so that repair techniques could be developed and tested before astronauts docked with the station.

The third Skylab crew's time in the station was extended from 56 days to 84 days so that the crew might observe and study comet Kohoutek up close. This crew set a record for time for American astronauts in space -- 84 days, which still stands today.

The third and final manned Skylab mission ended with a splash-down in the Pacific Ocean on February 8, 1974. The space station re-entered the earth's atmosphere over 5 years later, at 12:37 pm EDT, July 11, 1979, near southeastern Australia. After over six years in space the demise of the orbital workshop came on its 34,981st orbit.

A fitting conclusion to the Apollo-type mission was completed on July 24, 1975, with the completion of the Apollo-Soyuz Test Project (ASTP).

The primary ASTP mission objectives were: rendezvous and docking; crew transfer, and control center-crew interaction.

The mission plan was for a Russian Soyuz spacecraft with two cosmonauts aboard to be launched, and seven and one-half hours later a Saturn 1B was launched with three astronauts on board. Two days after launch, the two spacecraft docked together in space. During the next two days, the crews accomplished four transfer operations between the two spacecraft and completed five scheduled experiments. In addition, the crews provided television views of the interiors of the two spacecraft, and demonstrated various aspects of space operations.

This mission marked the first time that voice, TV, and telemetry data transmission were relayed between an orbiting Apollo spacecraft and the ground via the ATS-6 communications satellite.

Even before the giant Saturn V vehicles had completed their mission of sending astronauts to explore the moon, the need for a less expensive large launch vehicle had become obvious. In an effort to lower costs, NASA chose to employ a dramatically different concept, a reusable space vehicle. Hence the birth of the Space Shuttle, or Orbitor--a craft that takes off like a rocket, flies in space like a spacecraft, but returns to the earth and lands like a glider.

The big advantage is the reusability of the Orbiter. NASA engineers plan on being able to reuse each Orbiter for at least 100 missions.

The first flight of the Shuttle (named Columbia) occurred on April 12, 1981, with Astronauts John Young and Robert Crippen at the controls. The vehicle completed 35.6 orbits of the earth and landed safely at Edwards Air Force Base in California. The first four flights of the Shuttle were test flights, designed to check out the performance of the spacecraft. The second Shuttle flight became the first time a previously flown piloted space vehicle was re-used.

The first operational flight of the Shuttle was the Space Transport System (STS) 5 mission, launched on November 11, 1982. It was the first time four astronauts had been launched in one vehicle. Two commercial communications satellites were launched from the payload bay of the Shuttle.

On April 4, 1983, the second Shuttle Orbiter, Challenger, was launched with the STS-6 flight. Astronaut Story Musgrave tested a new space suit by doing an EVA in the cargo bay.

On June 18, 1983, STS-7 carried the first American woman into space--Dr. Sally Ride. Dr. Ride, a mission specialist, and four other crew members performed tasks with the remote manipulator arm.

Astronaut Guion Bluford, on August 30, 1983, became the first American black astronaut to fly in space, aboard STS-8. A total of six people made up this crew. The Shuttle for the first time was launched at night and returned to the earth at night.

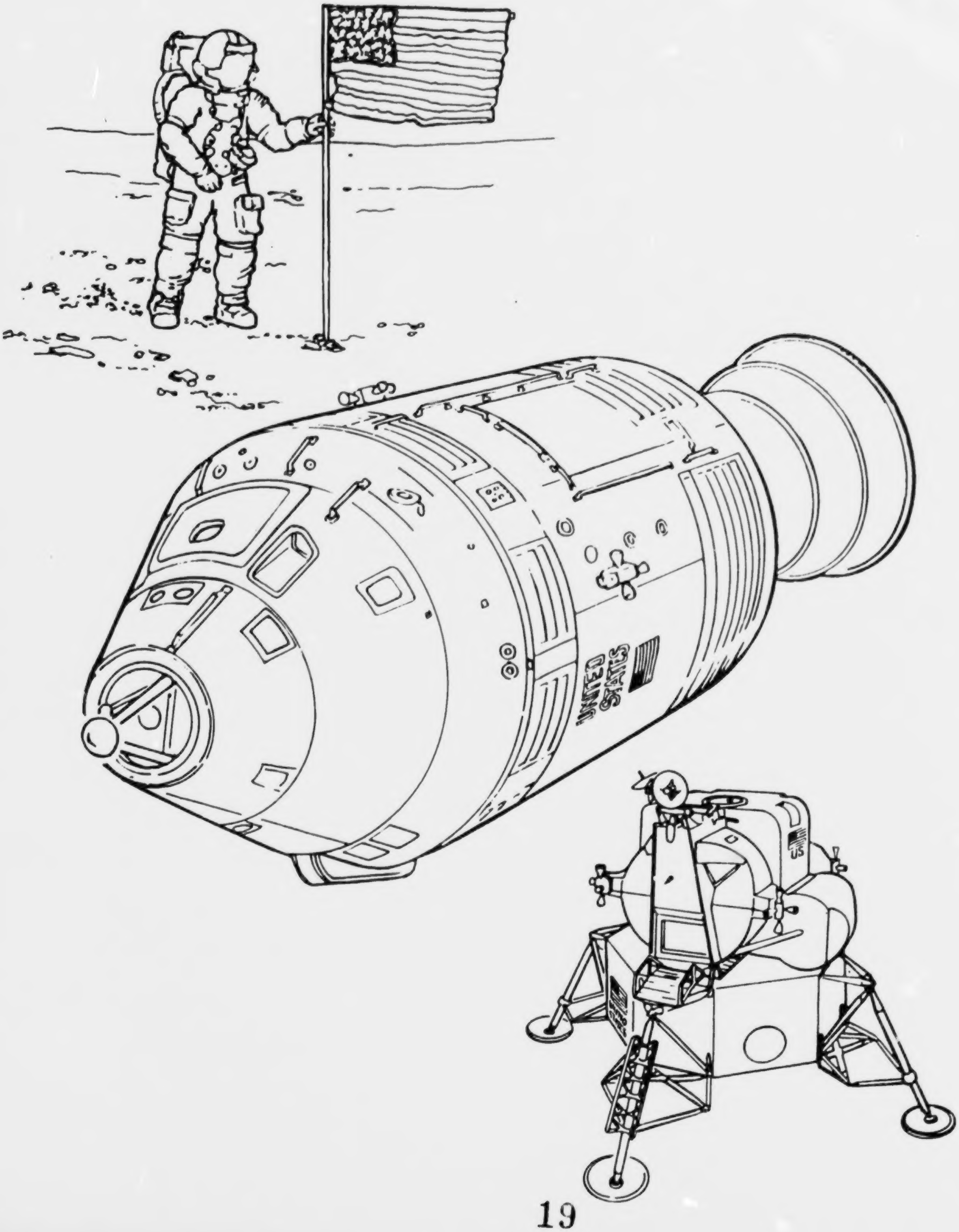
Spacelab, a European-made scientific lab, was flown for the first time aboard STS-9. The first non-NASA American astronaut, Ulf Merbold from West Germany, flew with Spacelab.

There are many more flights scheduled for the Shuttle through the 1980s and into the 1990s.

The question many people ask is, "What's next in the space program?". President Ronald Reagan, on January 25, 1984, committed this country to build and launch into earth orbit a large space structure (space station) by the early 1990s. This will probably accommodate six to eight people from six months up to a year. These space station crewmembers will have a variety of tasks to perform while in orbit, in addition to building the structure itself, in which many experiments and research projects can be conducted.

There has been talk of erecting a permanent lunar base on the moon's surface by approximately the year 2000. This base would be used for long-duration scientific research on the moon.

Probably the next step for human space flight after the projects such as the space station and the lunar base will be a flight to the planet Mars.


UNITED STATES
US

HISTORY OF HUMAN SPACEFLIGHT

Match the events listed below with the year in which the event occurred. Note: one of the dates can be used more than once.

(a) 1983
(b) 1865
(c) 1965
(d) 1973
(e) 1971
(f) 1959
(g) 1962
(h) 1981
(i) 1963
(j) 1961
(k) 1975
(l) 1969
(m) 1974
(n) 1968

________ 1. Neil Armstrong and Edwin Aldrin, Jr., became the first people to set foot onto the moon's surface.

________ 2. The Space Shuttle was launched for the first time with Astronauts John Young and Robert Crippen aboard.

________ 3. Sally Ride was the first American woman to fly in space, aboard STS-7.

________ 4. John H. Glenn, Jr., was the first American to orbit the earth. He completed three orbits in Friendship 7.

________ 5. Edward White II made the first U.S. spacewalk during the Gemini 4 mission.

________ 6. The first American astronaut in space, Alan Shepard, made a 15 minute suborbital flight in Freedom 7.

________ 7. Skylab, America's first space station, was launched, and three different crews worked and lived in a microgravity environment.

________ 8. Apollo-Soyuz, the joint U.S.-Russian spaceflight was launched.

________ 9. Gordon Cooper, Jr., flew on the last Mercury flight--Mercury 9

________10. The Lunar Rover Vehicle, the car used on the moon, was first used on Apollo 15.

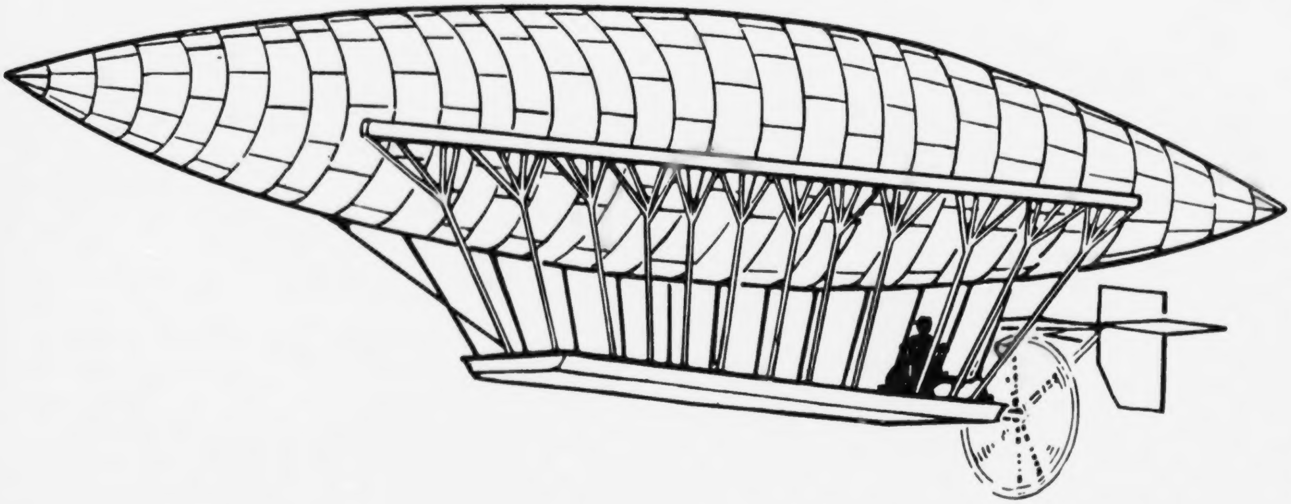
________11. Apollo 8 was the first flight to the moon. Astronauts were in orbit around the moon on Christmas Day.

________12. The last crew of astronauts who visited Skylab splashed down in the Pacific Ocean on February 8.

________13. Monkeys Able and Baker flew in space to test the effects of weightlessness on living creatures.

________14. Yuri Gagarin, Russian cosmonaut, became the first human to fly in space.

________15. Jules Verne, in his novel, "De la Terre a la Lune" (From the Earth to the Moon), put his passenger into a huge aluminum bullet, fired toward the moon from a giant cannon buried in Florida soil.



LIFE-SUPPORT SYSTEMS FOR THE ASTRONAUT

When astronauts travel into the hostile environment of space they must take everything they need to keep them alive and comfortable, and to return them safely to earth.

The spacecraft they ride in is a life-support system. It was developed to provide the conditions necessary to support life in a hostile environment, and to maintain communication with earth.

The atmosphere aboard the spacecraft must be controlled so that it provides an adequate breathing mixture under sufficient pressure. The oxygen that the astronauts breathe is carried in a liquid state and is converted to a gas when it is needed for breathing. The early missions used pure oxygen at 5 pounds of pressure per square inch. As the missions were extended to longer periods, such as Skylab, a mixture of oxygen and nitrogen was used.

The water supply must be managed to provide adequate amounts for drinking, personal hygiene, and humidity and temperature control. On some missions where electrictiy was produced by hydrogen fuel cells, the water produced by the cells was collected and used for personal needs.

The food the astronauts take with them must provide adequate nourishment, be appetizing, lightweight, convenient to use, and require very little space. On the early missions there was no refrigeration for food.

As the spacecraft begins to heat up it is necessary to maintain a comfortable temperature inside for the astronauts. In the Skylab program an air-conditioning system was developed to reduce the high temperature aboard.

Waste collection equipment and facilities are designed to overcome the microgravity environment. A method for storing wastes for later scientific analysis also is necessary.

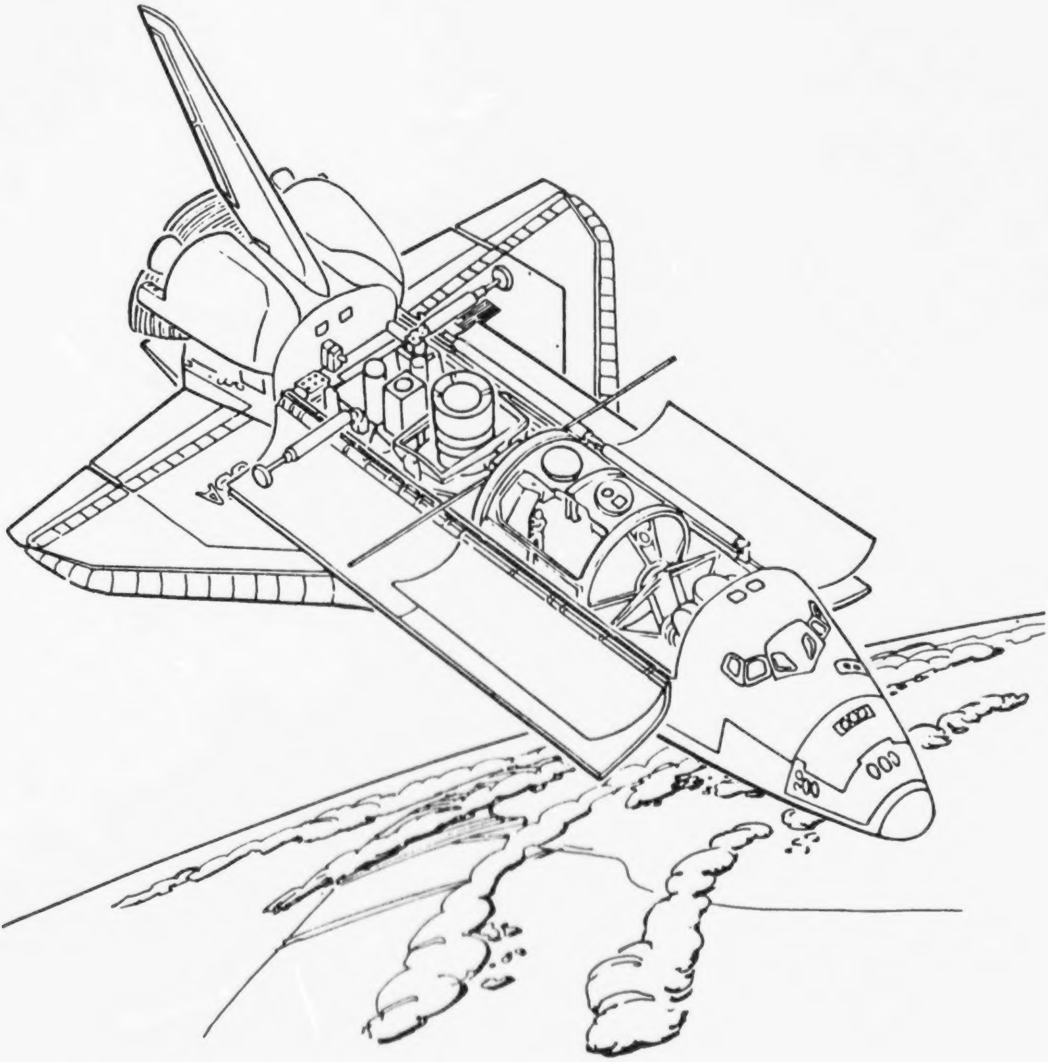
Methods were devised and facilities provided for exercising, brushing teeth, shaving, washing, and accomplishing other personal hygiene tasks.

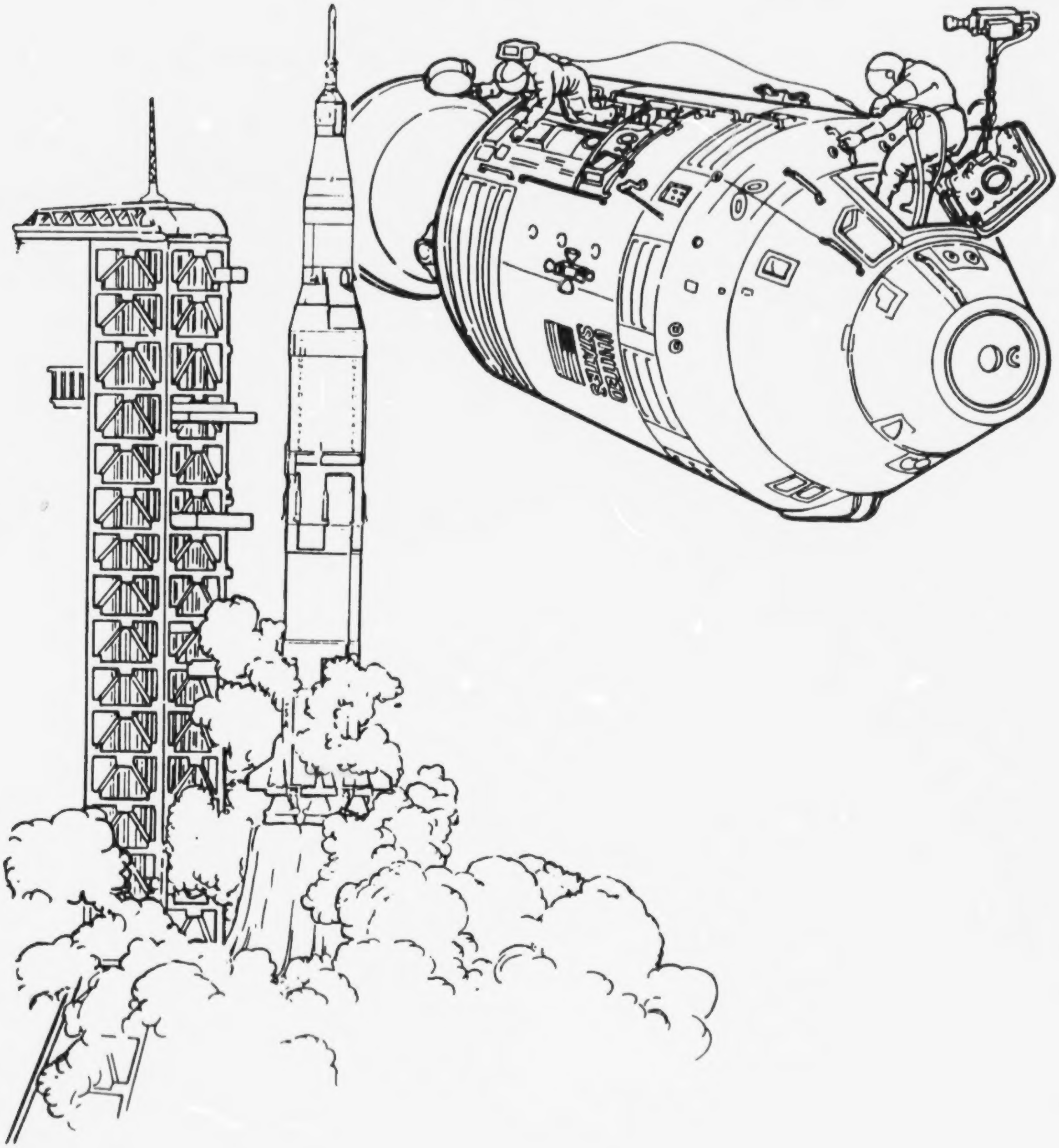
Instrument panels to measure and record many subsystems such as pressure, electric power, temperature, etc., and to warn of any malfunction are needed. Astronauts have to be trained to operate the many controls on each spacecraft.

It is necessary for mission control to communicate with the spacecraft. Information has to be collected from the astronauts as well as from the many instruments on board the craft.

The space suit, another form of life-support system, is designed to provide an artificial atmosphere. The suits enable the astronauts to leave the spacecraft for a period of time.

Another problem had to be handled -- that being the ability to re-enter the earth's atmosphere. The spacecraft must have some degree of maneuverability, and also be designed to reduce heat generated by the friction of re-entry. The early spacecraft had a heat shield that burned off during re-entry. The Shuttle has a new silica heat tile that is not destroyed during re-entry. This enables the craft to take very little turn-around time before the next launch, because the heat tiles do not need to be replaced.




UNITED STATES

FOOD FOR HUMAN SPACEFLIGHT

On February 21, 1962, Astronaut John Glenn became the first American to orbit the earth. His mission lasted nearly five hours before splashing down in the Atlantic Ocean. Glenn completed three trips aroung the world.

Among the tasks Glenn had to perform while in orbit were the first American space experiments in eating food in the weightless conditions of earth orbit. The flight was too short to make eating a necessity, but future flights were expected to last many days and even weeks. His experience would help design space food systems for future missions.

Eating in space for Glenn turned out to be an easy, though not very appetizing, experience. Some experts were worried before the flight that food would be hard to swallow in a weightless environment and would collect in the throat. Eating in weightlessness turned out to be relatively easy, and once the food reached the mouth, there was no problem in swallowing it. The Mercury astronauts who followed were forced to endure bite-sized cubes, freeze-dried foods, and semi-liquids in aluminum toothpaste-type tubes. They found the food unappetizing, had trouble rehydrating (adding water to) the freeze-dried foods, and disliked squeezing the tubes. Furthermore, crumbs from the bite-sized cubes had to be collected from the space vehicle cabins to prevent them from fouling instruments.

GEMINI

During the Gemini missions eating in space became more normal. Bite-sized food chunks were coated with an edible gelatin to reduce crumbling. Foods that had to be rehydrated were encased in improved plastic containers. To rehydrate food, water was injected into the pack through the nozzle of a water gun. After kneading the contents the food became moist and was squeezed through a tube into the astronauts's mouth.

A typical meal on a Gemini mission would include shrimp cocktail, chicken and vegetables, toast squares, butterscotch pudding, and apple juice. Before each flight, meal combinations were chosen by the astronauts themselves, but the menus chosen were required to provide 2,800 calories per day and include a balanced diet of vitamins, protein, carbohydrates and minerals.

APOLLO

In the Apollo program, food packages were similar to those used on the Gemini missions but the variety of food was considerably greater. Apollo astronauts had the added luxury of heated water for hot drinks and hot foods. With hot water available, food was easier to rehydrate and much improved in taste.

Further advances in Apollo food systems came with the introduction of the "spoon-bowl" package. Following rehydration of the contents of the spoon-bowl, a pressure type, plastic zipper was opened and the food removed with a spoon. The moisture content in the food enabled it to cling to the spoon as there was no assistance from gravity.

SKYLAB

Skylab food systems were much improved over systems used in Apollo, Gemini and Mercury. Skylab featured a large interior volume, and space was available for a dining table. The table was a pedestal where food trays were mounted. When dining, the astronauts would "sit down" in space by means of foot and thigh restraints and eat in an almost normal fashion. The food trays not only held the food in place but also served as warming devices as they were connected to a heating system.

Food containers for the Skylab astronauts consisted of aluminum cans with pull-off lids. Cans containing food had a built-in membrane to prevent spillage when removing the lid in weightlessness. Rehydratable foods were in a plastic pouch within the can and had a water valve for rehydration. Ready-to-eat foods were held in the can with a slit plastic cover. Instead of plastic bags, Skylab drinking containers were collapsible bottles that expanded accordian style when filled with hot or cold water. Some water bags used for backpacking and camping are very similar.

Knife, fork and spoon were held magnetically to the food tray until needed. A pair of scissors was added to the usual utensils for cutting open the plastic membranes.

Because of its relatively large storage space, Skylab was able to feature an extensive menu of 72 different food items. For the first time Skylab had a freezer for foods such as filet mignon and vanilla ice cream, and a refrigerator for chilling fruits and beverages. The astronauts, working with doctors, were able to plan their own menus.

APOLLO-SOYUZ

The Apollo-Soyuz Test Project with the Soviet Union in 1975 used the last Apollo spacecraft. Because of the craft design, no freezer or refrigerator could be used. However, many of the food advances from Skylab and the earlier Apollo missions were incorporated. Many short shelf-life items were added to the foods carried. Fresh breads and cheese were included as a part of 80 different varieties of food eaten by the crew.

The Apollo-Soyuz Test Project was a 5-day mission for the Russians. The American portion was for 7 days.

SPACE SHUTTLE

The Shuttle menu was designed to provide nutrition and energy requireme s essential for good health and effective performance with safe, h acceptable food.

centers around a galley that has been installed on the eck of the Orbiter's cabin. The galley can be removed for special missions that require extra interior space. It features hot and cold water dispensers, a pantry, an oven, food serving trays, a personal hygiene station, a water heater, and an auxiliary equipment storage area. The galley does not have a freezer or a refrigerator as in Skylab.

Meal preparation on the Shuttle is started by a crew member 30 to 60 minutes before mealtime. A full meal for a crew of four can be set up in about 5 minutes. Heating and reconstitution of the food takes an additional 20 to 30 minutes. The "chef" removes meal packages from storage and makes the necessary preparations before serving. Food needing rehydration is given hot or cold water in premeasured amounts. Water for rehydration comes from the Orbiter's fuel cells that produce electricity by combining hydrogen and oxygen gas. Water is a by-product.

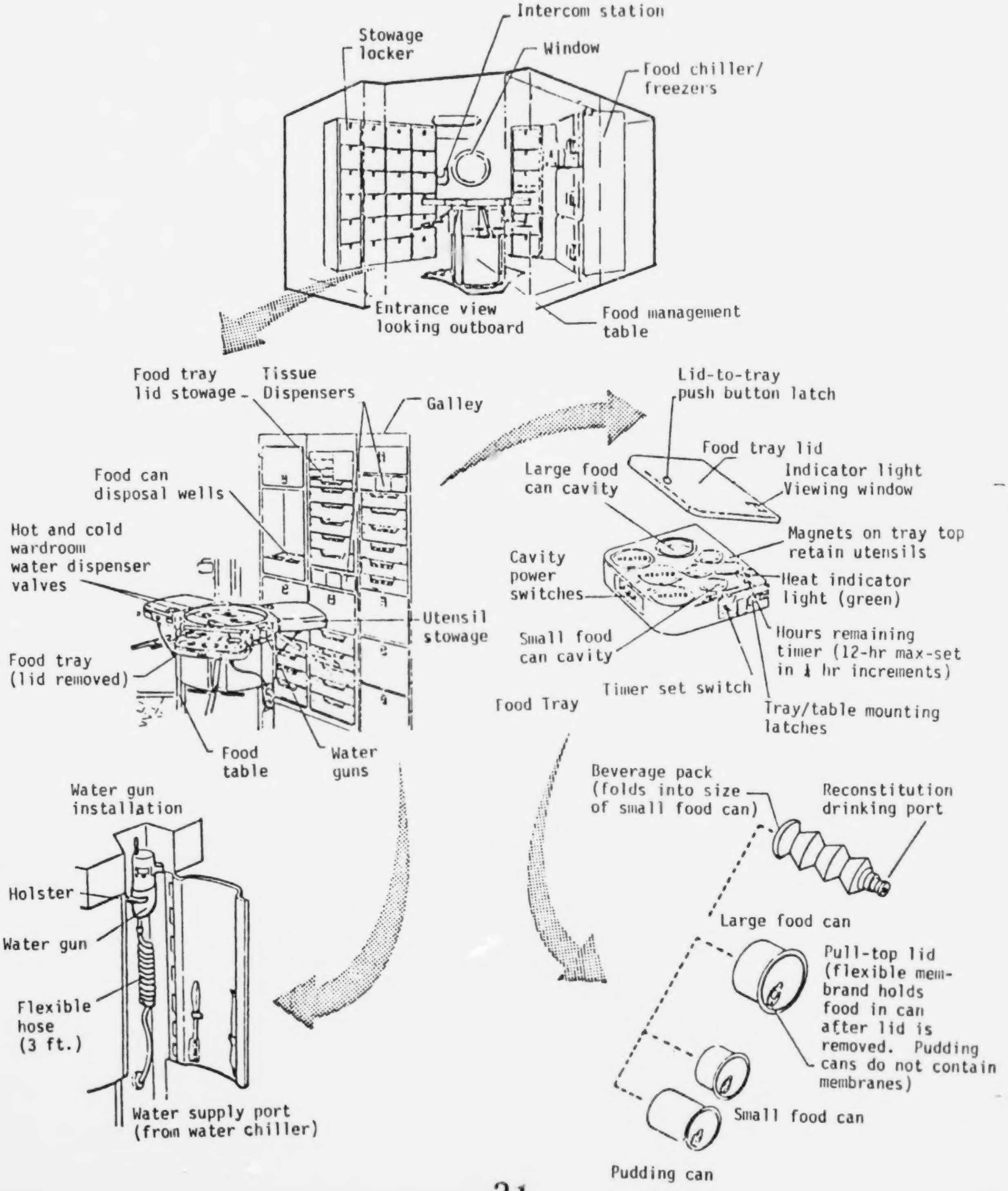
To simplify food packaging, a new rehydratable food pack was designed for the Shuttle. To add water, a large-gauge hollow needle is inserted through an opening in the base.

Food that needs to be heated is placed in a forced air convection oven, another new feature for space flights.

Beverage containers for the Shuttle are identical to the packages for rehydratables. A polyethylene straw is inserted through the same place that is used for injecting water.

Eating utensils consist of a knife, fork, spoon, and a pair of scissors for cutting open packages. Food can be seasoned with serving-sized packets of mustard, catsup, mayonnaise, hot sauce, and liquified salt and pepper. Following the meal, food containers are discarded within the Orbiter and the utensils and serving trays are cleaned with "wet wipes".

WARDROOM EATING FACILITIES


Intercom station
Stowage locker
Window
Food chiller/ freezers
Entrance view looking outboard
Food management table
Food tray lid stowage
Tissue Dispensers
Galley
Food can disposal wells
Hot and cold wardroom water dispenser valves
Utensil stowage
Food tray (lid removed)
Food table
Water guns
Lid-to-tray push button latch
Food tray lid
Large food can cavity
Indicator light
Viewing window
Magnets on tray top retain utensils
Cavity power switches
Heat indicator light (green)
Small food can cavity
Hours remaining timer (12-hr max-set in ¼ hr increments)
Timer set switch
Tray/table mounting latches
Food Tray
Water gun installation
Holster
Water gun
Flexible hose (3 ft.)
Water supply port (from water chiller)
Beverage pack (folds into size of small food can)
Reconstitution drinking port
Large food can
Pull-top lid (flexible mem- brand holds food in can after lid is removed. Pudding cans do not contain membranes)
Small food can
Pudding can

Read the information on "Food for Human Spaceflight". Then answer the following questions.

1. Before the Mercury astronauts flew in space, what did some experts think would happen if people tried to eat in space?______________

____

2. What coating was used for bite-sized food chunks on Gemini?________

____

3. Why did the food need to be coated?______________________________

____

4. What types of tubes were used to store food in on Mercury missions?

____

5. What was used in Gemini to add water to food packages?___________

____

6. How many calories were required to be eaten by the Gemini astronauts each day:____

7. On what mission did the astronauts first have heated water?_______

____

8. How were "spoon-bowl" containers opened and closed?______________

____

9. A dining room table was first used on the ______________________ mission.

10. The astronauts would "sit down" in space by means of ____________ and ______________restraints.

11. What would be a better description than "sit down"?______________

____

12. Food containers on the Skylab missions consisted of ____________ cans.

13. What kind of drinking containers were used on Skylab?____________

____

14. How were eating utensils held in place on the Skylab food tray?___

____

15. How many different food items were on the Skylab menu?___________

16. For the first time Skylab had two new units added to assist in the food program. List them. ____________________ and ________________________.

17. Fresh bread and cheese were first flown on what mission?__________

18. What is the center of the Shuttle's food preparation set-up?______

____

19. Does the Shuttle carry a refrigerator or freezer on board?________

20. Water that is used for rehydrating the food on board the Shuttle comes from ____

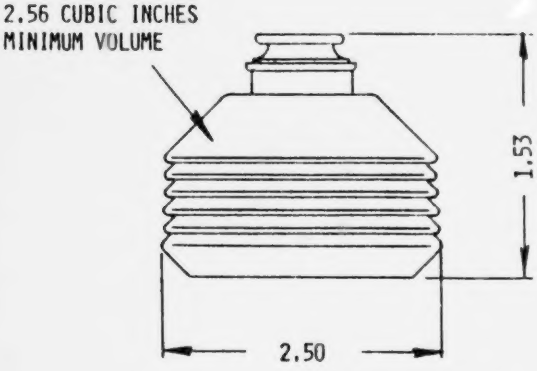
____

21. What type of salt and pepper is used for seasoning food aboard the Shuttle?____

22. Why are the salt and pepper in this form?_________________________

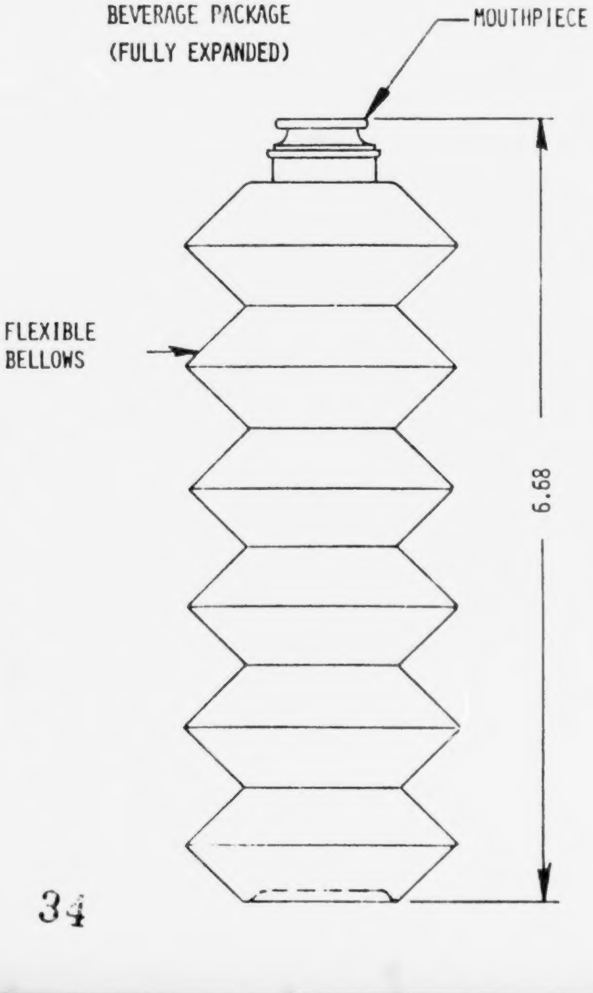
____

BEVERAGE PACKAGE
(FULLY COLLAPSED)


2.56 CUBIC INCHES
MINIMUM VOLUME
1.53
2.50

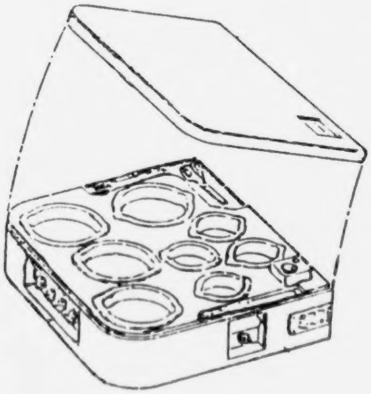
TOTAL LENGTH VARIES FROM 1.53 TO 3.90
WITH VARIOUS FOOD VOLUMES

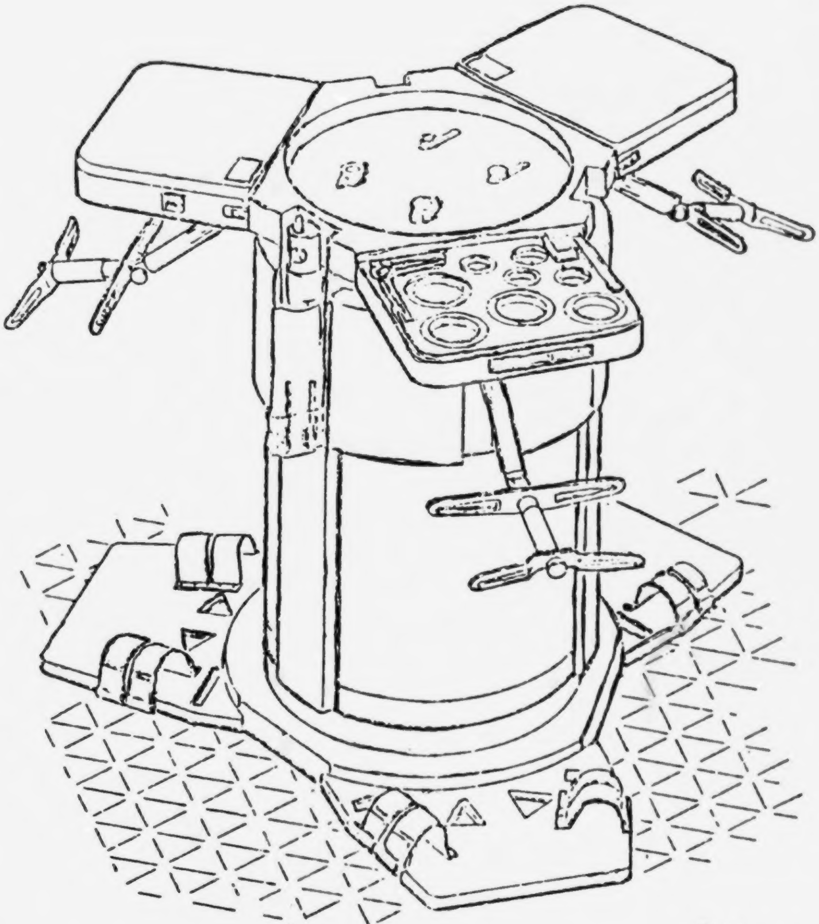
BEVERAGE PACKAGE
(FULLY EXPANDED)


MOUTHPIECE
FLEXIBLE
BELLOWS
6.68

WARDROOM EATING FACILITIES

TABLE AND TRAY





APOLLO XI (ARMSTRONG)

MEAL	DAY 1*, 5	DAY 2	DAY 3	DAY 4
A	Peaches	Fruit Cocktail	Peaches	Canadian Bacon/Applesause
	Bacon Squares (8)	Sausage Patties**	Bacon Squares (8)	Sugar Coated Corn Flakes
	Strawberry Cubes (4)	Cinn.Toast Bread Cubes (4)	Apricot Cereal Cubes(4)	Peanut Cubes (4)
	Grape Drink	Cocoa	Grape Drink	Cocoa
	Orange Drink	Grapefruit Drink	Orange Drink	Orange-Grapefruit Drink
B	Beef and Potatoes***	Frankfurters***	Cream of Chicken Soup	Shrimp Cocktail
	Butterscotch Pudding	Applesauce	Turkey/Gravy***	Ham and Potatoes***
	Brownies (4)	Chocolate Pudding	Cheese Cracker Cubes (6)	Fruit Cocktail
	Grape Punch	Orange-Grapefruit Drink	Chocolate Cubes (6)	Date Fruitcake (4)
			Pinapl./Grapefruit Drink	Grapefruit Drink
C	Salmon Salad	Spaghetti/Meat Sauce**	Tuna Salad	Beef Stew**
	Chicken and Rice**	Pork/Scallop Potatoes**	Chicken Stew**	Coconut Cubes (4)
	Sugar Cookie Cubes (6)	Pineapple Fruitcake (4)	Butterscotch Pudding	Banana Pudding
	Cocoa	Grape Punch	Cocoa	Grape Punch
	Pinapl./Grapefruit Drink		Grapefruit Drink	

* Day 1 consists of Meal B and C only.
** Spoon-Bowl Package.
*** Wet-Pack Food.

SKYLAB

MEAL	DAY 1	DAY 2	DAY 3
A	Scrambled Eggs Sausage Patties Strawberries Bread/Jam Orange Juice Coffee	Cornflakes Chocolate Instant Breakfast Grape Drink Coffee	Scrambled Eggs Sausage Biscuit Cocoa Coffee
B	Chicken and Gravy Asparagus Peaches Biscuit Cocoa Lemonade	Cream of Potato Soup Chicken and Rice Pre-buttered Roll Peaches Lemonade	Cream of Potato Soup Pork/Scalloped Potatoes Green Beans/Cheese Sauce Pears Grape Drink
C	Veal/Barbeque Sauce Mashed Potatoes Green Beans/Cheese Sauce Peach Ambrosia/Pecans Grapefruit Juice	Filet Mignon German Potato Salad Pears Biscuit Cocoa Grape Drink	Lobster Newberg Mashed Potatoes Asparagus Vanilla Wafers Vanilla Ice Cream Lemonade
Snacks	Coffee x 2 Butterscotch Pudding	Coffee x 2	Coffee x 2 Dried Apricots

Activity: Read *Food for Human Spaceflight* and the sample menus. On the Skylab menu, place the appropriate symbol beside each food: T = Thermostabilized; W = Wafer or Bite-size; F = Frozen; R = Rehydratable; B = Beverage.

APOLLO-SOYUZ FLIGHT MENU

MEAL	DAY 1*, 5, 9		DAY 2, 6, 10		DAY 3, 7, 11**		DAY 4, 8	
A	Breakfast roll	NF	Scrambled eggs	R	Granola	R	Scrambled eggs	R
	Raisen/spice cereal	R	Bacon wafers (4)	NF	Beef patties	R	Sausage patties	R
	Peaches	R	Strawberries	R	Dried peaches	C	Pineapple	TC
	Orange drink	R	Grapefruit crystals	R	Cocoa	R	Orange drink	R
	Coffee, cream/sugar	R	Tea, lemon/sugar	R			Coffee, cream/sugar	R
B	Pea soup	R	Chicken salad	TC	Turkey-rice soup	R	Potato soup	R
	Salmon	TC	Crackers	NF	Cheese crackers	NF	Beef slices/BBQ sauce	TP
	Rye bread	NF	Cheese slice	NF	Peanut butter	TP	Cheese spread	TP
	Dried apricots	C	Applesauce	TC	Strawberry jam	TP	Rye bread	NF
	Smoked almonds	NF	Orange crystals	R	Rye bread	NF	Peach ambrosia	R
	Lemonade	R			Tea, lemon/sugar	R	Strawberry drink	R
C	Shrimp cocktail	R	Seafood/mushroom soup	R	Shrimp cocktail	R	Seafood mushroom soup	R
	Beef steak	TP	Meatballs/BBQ sauce	TP	Chicken ala king	TP	Turkey/gravy	TP
	Creamed corn	R	Potato patties	R	Peas	R	Cranberry sauce	TC
	Vanilla pudding	TC	Stewed tomatoes	TC	Pears	R	Brownies	NF
	Orange/pinapl. drink	R	Cherry nut cake	TP	Chocolate nut cake	TP	Grapefruit drink	R
			Strawberry drink	R	Orange/pinapl. drink	R	Peanuts	NF

* Day 1 consists of Meal C only
** Day 11 consists of Meals A and B only

10 day food supply

NF - Natural form
C - Can
TP - Thermostabilized, pouch
TC - Thermostabilized, can
R - Rehydratable

Identify foods that provide protein, vitamins, fiber, and carbohydrates in each day's meals. Make a chart or table. Why are each of these important?

ASTP FLIGHT MENU

The following menus were selected by the Soyuz cosmonauts for joint meals aboard Apollo:

Aleskey A. Leonov		Valariy N. Kubasov	
Potato soup	R	Seafood mushroom soup	R
Beef steak (I)	TP	Beef steak (I)	TP
Rye bread	NF	Rye bread	NF
Cheese spread	TP	Cheese spread	TP
Almonds	NF	Almonds	NF
Strawberries	R	Strawberries	R
Tea w/lemon, sugar	R	Tea w/lemon, sugar	R

NF - Naturalform
R - Rehydratable
TP - Thermostabilized, pouch
T - Thermostabilized
I - Irradiated

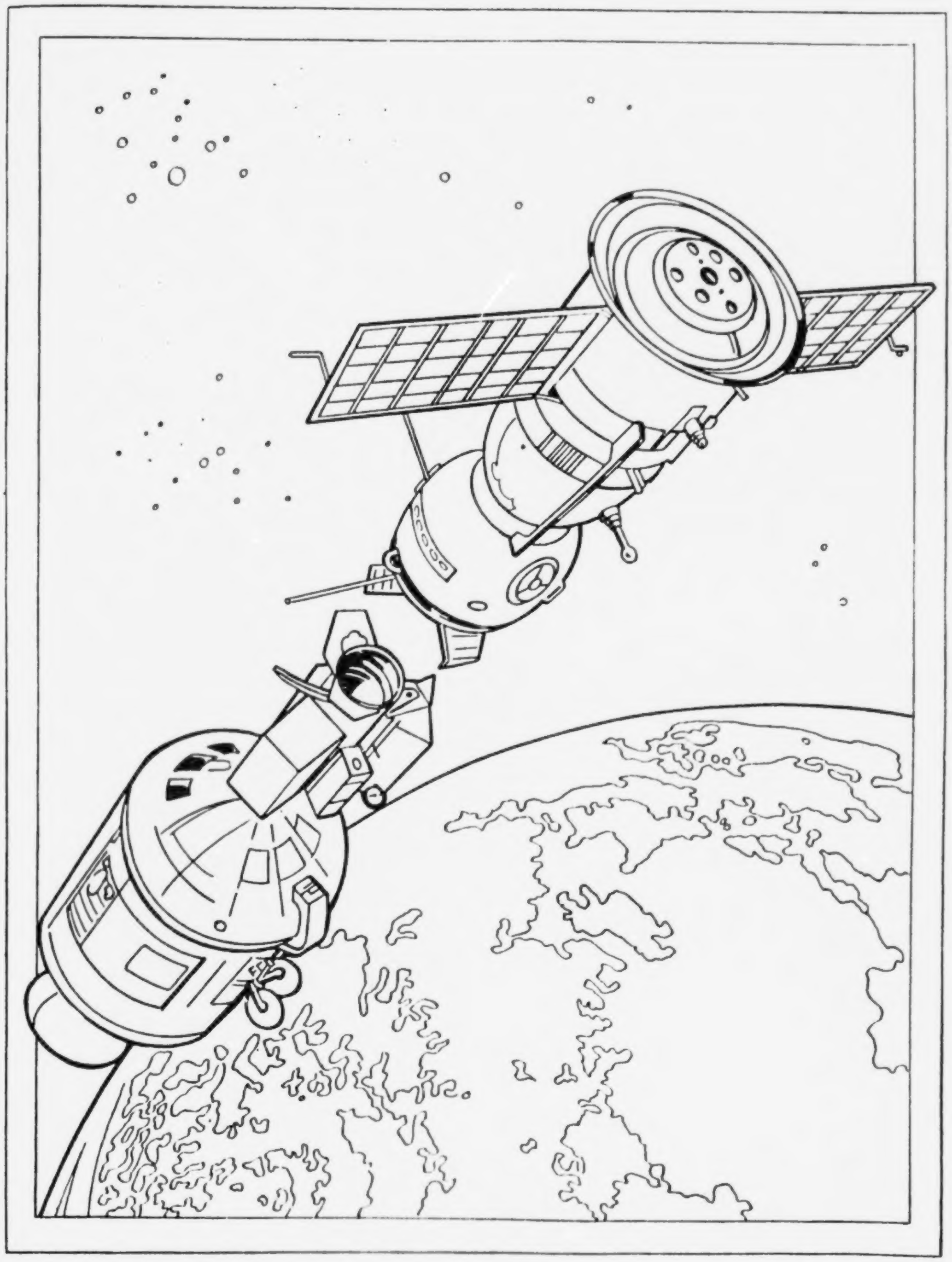
Imagine you were a guest on Apollo. From the foods available on the previous page design a nutritious, balanced meal which includes food with at least three of the following forms: NF, R, TP, T.

TYPICAL MENU FOR THE FIRST FOUR SHUTTLE FLIGHTS*

DAY 1	DAY 2	DAY 3	DAY 4
Peaches (T)	Applesauce (T)	Dried peaches (IM)	Dried Apricots (IM)
Beef patty (R)	Beef jerky (NF)	Sausage (R)	Breakfast roll (NF)
Scrambled eggs (R)	Granola (R)	Scrambled eggs (R)	Granola w/blueberries (R)
Bran flakes (R)	Breakfast roll (NF)	Cornflakes (R)	Vanilla instant breakfast (B)
Cocoa (B)	Chocolate inst. breakfast (B)	Cocoa (B)	Grapefruit drink (B)
Orange drink (B)	Orange-grapefruit drink (B)	Orange-pineapple drink (B)	
Frankfurters (T)	Corned beef (T)	Ham (T)	Gr. beef/pickle sauce (T)
Turkey tetrazzini (R)	Asparagus (R)	Cheese spread (T)	Noodles/chicken (R)
Bread (NF)	Bread (NF)	Bread (NF)	Stewed tomatoes (T)
Bananas (FD)	Pears (T)	Green beans/broccoli (R)	Pears (FD)
Almond crunch bar (NF)	Peanuts (NF)	Crushed pineapple (T)	Almonds (NF)
Apple drink (B)	Lemonade (B)	Shortbread cookies (NF)	Strawberry drink (B)
		Cashews (NF)	
		Tea, lemon, sugar (B)	
Shrimp cocktail (R)	Beef, barbeque sauce (T)	Cream of mushroom soup (R)	Tuna (T)
Beef steak (T)	Cauliflower w/cheese (R)	Smoked turkey (T)	Macaroni and cheese (R)
Rice pilaf (R)	Green beans w/mushrooms (R)	Mixed Italian veget. (R)	Peas w/ butter sauce (R)
Broccoli au gratin (R)	Lemon pudding (T)	Vanilla pudding (T)(R)	Peach ambrosia (R)
Fruit cocktail (T)	Pecan cookies (NF)	Strawberries (R)	Chocolate pudding (T)(R)
Butterscotch pudding (T)	Cocoa (B)	Tropical punch (B)	Lemonade (B)
Grape drink (B)			

T - thermostabilized; I - irradiated; IM - intermediate moisture; FD - freeze dried; R - rehydratable; NF - natural form; B - beverage.

Note: Beginning with the fifth Shuttle flight, the menu cycles were enlarged to six days.



SPACE MENU ACTIVITIES

The crew on a spaceflight of any length of time of more than a few hours will require food and liquids. In the early days of spaceflight the crew cabin had no stove or refrigerator onboard. This meant that all food carried onboard had to be of the kind that required no cooking or refrigerating. In later missions a convection oven and a refrigerating system were placed onboard.

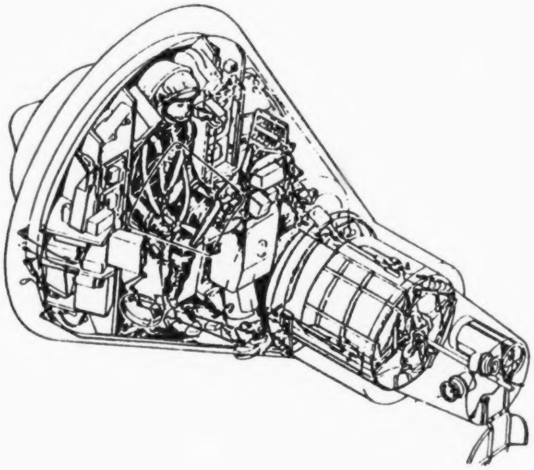
Discuss with students the importance of a well-balanced meal, with a variety of different foods included.

Discuss the following questions:

How would food be packaged?
What kind of eating utensils would one use in space?
How would you package a liquid and how would one drink a liquid in space?
How might one solve problems of eating in an environment where everything floats around?
Would there be any advantages of eating in an environment where things float?
How would you handle seasoning of food in space?
What would happen if foods contained a certain amount of air?
Is it important that the food tastes good and be pleasant looking to the austronaut's eye? Why?
How would you make the food more like what we eat here on earth?

Allow students the opportunity to discover how NASA attempted to solve these problems. In groups they could experiemnt with paper, plastic, and other materials, and try to design containers and other means of dealing with the problems. They could bring materials from home. They can also share their results and evaluate their own or one anothers' efforts.

Have the students develop a menu for a 2-week space flight, first with the early flights in mind, then one for later missions.



DRESSED FOR SPACEFLIGHT

Space is hostile and deadly to the unprotected human because it lacks the atmospheric pressure, oxygen, and temperature control to sustain life. Without the filtering effects of the earth's atmosphere, the sun's heat can raise the temperature of an object in space to as high as 250 degrees Fahrenheit, and can lower the temperature to as low as 250 degrees below zero in the shadow.

The first pressure suit or spacesuit was designed to be worn by Wiley Post (1934), a world-renowned aviator who was attempting to set a high-altitude record in an airplane. The suit designed and built for Post resembled the type usually worn by deep-sea divers.

MERCURY

One of the first true spacesuits was developed for the Mercury program. It was designed after the U.S. Navy's Mark IV pressure suit which was used in high-speed flight. The suit was worn in case the spacecraft's environmental control system failed. The Mercury spacecraft's design played a large role in the development of the suit eventually worn during a mission.

The interior of the spacecraft was small, and the design of the craft's controls was such that mobility was not a prime requirement except for shoulder and hand movement. With the short-duration flights, waste management could be achieved by proper pre-flight diet and the use of a urine collection device in the suit.

In the Mercury suit, oxygen was fed into the garment by a connector located in the torso area. The oxygen was first circulated to the extremities of the suit and then to the helmet for breathing. Exhaled waste bled off through a headpiece connector into the environmental control system where it was re-constituted for re-use.

The suit was usually made of four layers of loosely fitted material. The outer layer was a high-temperature-resistant metallic fabric. The second layer was a woven net fabric which served as a restraint layer to prevent the suit from ballooning when pressurized. The third layer was a rubberized fabric designed to make the suit airtight. The inner layer next to the astronaut's body was a smooth soft nylon designed for comfort.

The helmet for the spacesuit, attached to a special neck ring, was padded to prevent head injury. The astronaut's communications systems were built into the helmet. Gloves and custom-made boots completed the spacesuit.

GEMINI

In the two-man spaceflight program, Gemini, NASA faced the problem of developing a fully pressurized spacesuit that would allow a member of the crew to leave the spacecraft for varying lengths of time and to operate in a micro-gravity environment of extreme temperature differences.

The basic Gemini suit had some similarity to the Mercury suit. It was a multilayered garment consisting of an inner comfort liner, a gas bladder, a structural restraint layer, and an outer protective cover. To make the suit easier to put on and take off, quick disconnectors were located at the wrists for gloves, at the neck for the helmet, and at the waist for ventilation-gas connections.

A pressure-sealing zipper was added to make dressing and undressing easier. Body wastes were taken care of by a disposal system built into the suit. The basic suit was also provided with handkerchief, pencils, survival knife, scissors, neck and wrist dams (worn during recovery operations after gloves and helmet have been removed to prevent water from entering the suit), a parachute harness, and special built-in pockets on the arms and legs to hold flight books and charts.

On the Gemini 4 mission, an astronaut left the spacecraft to become the first American to walk in space. For this new experience, the suit had to be slightly modified. A different extravehicular (EVA) outer layer was added to the basic suit as well as pressure-thermal gloves, a helmet visor with temperature control coating, and a sun visor. The EVA outer layer consisted of nylon material for micro-meteoroid protection, seven layers of aluminized superinsulation, and an outer covering of high-temperature resistant nylon cloth.

An additional change in the Gemini spacesuit was made for the Gemini 7 flight. A "lightweight" suit was designed for use within the spacecraft only. Its purpose was to provide maximum protection as well as comfort and freedom of movement.

The suit had a soft fabric hood which replaced the hard pre-shaped helmet worn previously. The lightweight suit weighed only 16 pounds.

The new suit had two layers of material: the inner layer was the pressure-restraining neoprene-coated nylon bladder, and the outer layer was 6-ounce high-temperature resistant nylon. The new suit made it possible to travel in a shirtsleeve environment.

Other changes in the Gemini spacesuit occured on Gemini 8. The outer protective cover, or micrometeoroid layer, was reduced. On Gemini 9, changes were made in the lower portion of the Astronaut Maneuvering Unit (AMU).

APOLLO

The Apollo spacesuit had to provide the astronauts with protection. It had to protect them from temperatures ranging from -250 to +250 degrees F. Not only did the moon explorers' spacesuits have to offer protection from jagged rocks and the searing heat of the lunar day, but the suit also had to be flexible enough to permit stooping and bending as the crewmen gathered samples from the Moon.

A backpack portable life support system provided breathing oxygen, suit cooling, and pressurization for moonwalks lasting up to 8 hours.

The Apollo space suit's mobility was improved over earlier suits by the use of bellows-like joints at the elbows and knees.

From the body out, the Apollo spacesuit began with a liquid-cooling garment similar to a pair of long underwear with a network of spaghetti-like tubing sewn into the fabric. Cool water, circulated through the tubing, transferred the body heat from the astronaut's body to the backpack and thence to space.

Next was a layer of lightweight heat-resistant nomex, followed by a gastight bladder of Neoprene-coated nylon, a nylon resistraint layer to prevent the bladder from ballooning, a lightweight super-insulation of alternating layers of thin Kapton and glassfiber cloth, several layers of Mylar and space material, and finally, protective outer layers of Teflon-coated glassfiber Beta cloth and Teflon cloth. The suit had a total of 21 layers of material in its makeup.

The Apollo helmet was formed from high-strength Lexan plastic, and was attached to the spacesuit by a pressure-sealing neckring. Unlike the Mercury and Gemini helmets, the Apollo helmet was fixed and the astronaut's head was free to move about inside. While walking on the moon, Apollo astronauts wore an outer visor over the bubble helmet to shield against eye-damaging ultraviolet radiation.

SKYLAB

Skylab astronauts wore a simplified version of the Apollo spacesuit. The changes in the suit included a lightweight thermal micrometeoroid overgarment, elimination of the lunar boots, and a simplified visor shell over the helmet. An umbilical life-support cord replaced the backpack during spacewalks.

APOLLO-SOYUZ

Apollo-type space suits were used again for the joint Apollo-Soyuz Test Project. The astronauts were equipped with an Apollo spacesuit fitted with a simple cover layer replacing the thermal micrometeoroid layer, since no spacewalks were planned. The cosmonauts had "skafandr" available in the event of pressure-loss in the spacecrafts.

SPACE SHUTTLE

After the first four shuttle flights spacesuits are no longer required to be worn during liftoff or re-entry as on earlier space missions. Spacesuits are required if an extravehicular activity is planned. The shuttle space suits come in three sizes -- small, medium and large. The suits are designed to accomodate both male and female astronauts. No longer are suits tailored for individuals as in earlier programs.

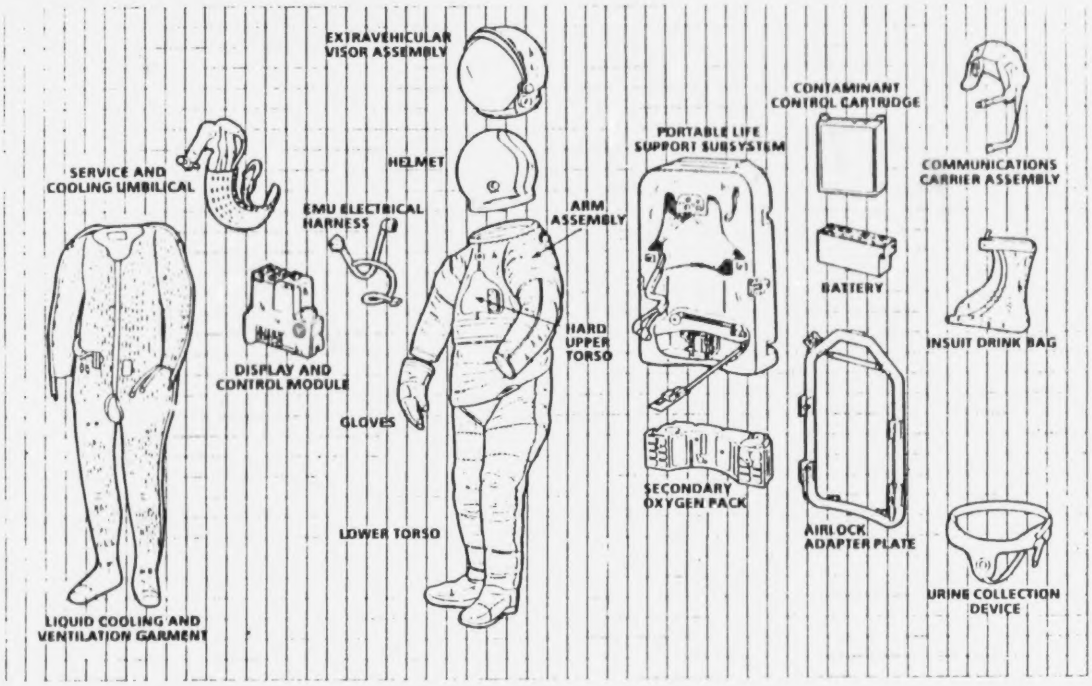
To put on the spacesuit, the shuttle astronaut enters an airlock drum where the suit is stored. First he or she puts on a pair of longjohns and a urine-collecting device. The longjohns have water-cooling tubes running through them to keep the wearer comfortable during the heavy outside work. Next he/she "rises" into the top section of the two-piece suit fastened to the wall and then gets into the lower part.

The shuttle space suit is a remarkable feat of engineering. A built-in backpack in the upper section contains a miniature life support system similar to the shuttle's system. The backpack contains oxygen for circulation through the helmet and the inside layer of the space suit, a fan to move the air, a small lithium hydroxide canister with a layer of charcoal to remove carbon dioxide and other unwanted gasses, water and a pump to dispatch it into the tubes in the longjohns, a unit to cool the water and get rid of the heat from the astronaut's body, and batteries to power it. There is even a water purifier, so drinking water can be sipped inside the helmet.

The suit has a series of layers. The basic layer is an inflatable bladder that is filled with oxygen to create a uniform pressure around the body. A restraint layer of dacron-polyester over the bladder prevents it from ballooning. Next are several layers of fireproof fabric and flexible metal to provide insulation against radiation and temperature changes in space. A layer of hard metal joins the top and bottom sections of the space suit into a unit.

A new and exciting piece of equipment has been added to the shuttle space suit. It is called a Manned Maneuvering Unit (MMU). The MMU is a one-person, gas-propelled backpack that snaps onto the space suit's portable life support system. Rotational and translational hand controllers allow the crewmember to fly with precision in or around the shuttle's payload bay or to nearby free-flying payloads or structures, and to reach many otherwise inaccessible areas outside the orbiter.

**SPACE SUIT/LIFE SUPPORT SYSTEM
OR EXTRAVEHICULAR MOBILITY UNIT**


EXTRAVEHICULAR VISOR ASSEMBLY
HELMET
SERVICE AND COOLING UMBILICAL
EMU ELECTRICAL HARNESS
ARM ASSEMBLY
DISPLAY AND CONTROL MODULE
HARD UPPER TORSO
GLOVES
LOWER TORSO
LIQUID COOLING AND VENTILATION GARMENT
PORTABLE LIFE SUPPORT SUBSYSTEM
SECONDARY OXYGEN PACK
CONTAMINANT CONTROL CARTRIDGE
BATTERY
AIRLOCK ADAPTER PLATE
COMMUNICATIONS CARRIER ASSEMBLY
INSUIT DRINK BAG
URINE COLLECTION DEVICE

The "Dressed for Spaceflight" unit will help you find the answers to these questions.

1. Who was the first pressure suit designed for?____________________

2. How many layers are there in a Mercury suit?____________________

3. What was added to the Gemini suit which made it easier to put on and take off?____________________

4 Why did the space suit on Gemini 4 have to be modified?__________
____

5. When was the Gemini "lightweight" suit first used?______________
____

6. What did the Gemini "lightweight" suit allow the astronauts to do?
____

7. The Apollo space suits had to be flexible enough to allow the astronauts ____________________and____________________.

8. How long could astronauts stay out on the moon?__________________

9. In the Apollo space suit, what purpose did the longjohns serve?
____

10. How many layers did the Apollo suits contain?__________________

11. Why was an outer visor worn over the helmet during moon walks?

____

12. What was eliminated from the Apollo type suit for Skylab missions?____

13. Why was it eliminated?______________________________________

WASTE MANAGEMENT SYSTEMS
FOR HUMAN SPACEFLIGHT

For astronauts to live comfortably and safely in the closed environment of a spacecraft, the management of human waste is among the life support functions which must be carried out efficiently. A spacecraft's waste management system must be reliable, sanitary, and psychologically acceptable to the crew. Systems to handle crew members' bodily wastes have evolved from simple assemblies used on Mercury flights to the present-day complicated equipment on board the space shuttle orbiters. The systems have become easier to operate and more earth-like, a feat difficult to accomplish in the zero gravity of space, where materials and liquids tend to float about in a state of "weightlessness".

MERCURY

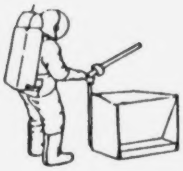
When Mercury flights began to extend into durations of over an hour, provisions were made for handling human waste matter. Astronauts wore a urination bag contained in their spacecuits. On the flight of Mercury-Atlas 9, which lasted more than 24 hours, astronauts used a waste management system made up of two units, a urination bag and a storage bag with a syringe-pump and hose. The syringe provided pressure to draw the urine from the in-suit bag to the storage bag.

Bags for defecation were not provided for any of the Mercury missions. Crewmen ate a low-residue diet for three days prior to launch so they would not have a bowel movement. They carried emergency containers for emesis (vomiting), if vomiting should occur, on each of the Mercury missions.

During the Gemini program, astronauts used a system similar to that used in the Mercury program. It consisted of one urination bag for use during launch and another for use in-flight. The bag used during launch was Y-shaped. It fit on the inside of the spacesuit around the pelvis. The bag had two openings, one with a fitted rubber sleeve that the astronaut attached to his body, and another opening used for emptying the bag. The waste was dumped overboard the spacecraft through an overboard dump system.

The other system was used after the astronauts attained orbit. It was a flexible bag with a roll-on rubber sheath. The voided urine was then vented overboard.

Gemini missions 7 and 9 had a sample valve which allowed the astronauts to draw off a specimen of urine for medical examination back on earth.



The feces could not be flushed overboard like the liquid waste because of the possibility of comtaminating instruments on the outside of the spacecraft. On Gemini flights, the astronauts used a plastic bag with a 4-inch circular opening to collect the feces. First the astronaut placed a germicidal pouch in the bag to prevent or reduce gas and bacterial growth. Then he attached the bag to his buttocks using surgical-adhesive tape. After defecation, he removed the bag, placed soiled toilet tissues in it, and pressed the adhesive surfaces firmly together. The bags were then returned to earth in the spacecraft.

As in the Mercury program, Gemini astronauts ate low-residue foods prior to their flights and took emesis containers on the spacecraft.

APOLLO

For the manned missions to the moon in the Apollo program, provisions had to made for collecting, inactivating, and stowing feces for 14-day periods.

The feces collection assemblies consisted of an inner bag, germicide, and an outer bag. The inner bag was nearly identical to and was used the same way as the bag in the Gemini program. After use the inner bag was placed in the outer bag, pressed to rupture the germicide pouch, and stowed in a waste compartment. The compartment was vented to space to remove odors.

There was also a fecal containment system worn by the astronauts under their pressurized suits during extravehicular activities. The system functioned like a baby's diaper to allow for emergency defecation. It was an elastic underwear with an absorbent liner around the buttock area.

There were basically two modes for collecting urine, depending on whether or not the astronaut wore his pressurized spacesuit. While wearing his spacesuit, an astronaut urinated into a detachable roll-on cuff connected to a flexible rubber-coated fabric bag. The urine collection systems of the command module and the lunar module had a basic difference. The system in the command module dumped the urine overboard; the system in the lunar module stored it to prevent contamination of the lunar surface.

In the command module, the astronauts used either a funnel or a roll-on cuff receiver with a bag and an outlet for attachment to the waste management system. Each Apollo crewman had his own cuff-and-bag device.

SKYLAB

In Skylab, the waste management facilities were a challenge to spacecraft designers for several reasons, one being the length of the missions (28, 59, and 84 days). Another reason was a set of extensive requirements for associated medical experiments. Samples of body wastes were required to assess the bone and muscle changes in astronauts exposed to weightlessness over a long period. All solid human waste products were to be dried, and the residue returned to earth for examination and analysis. Daily urine samples had to be frozen for later analysis on the ground.

The fecal/urine collector, analogous to a toilet, was mounted on the wall. In the weightlessness of space, the user appeared to sit on the wall, facing the floor.

An electric blower provided an airflow (suction) to aid in stool separation and draw the waste into the bag under the commode seat. The bag was removed after each defecation, weighed with its contents, labeled, and vacuum-dried in a waste processor for 16 to 20 hours. Then the bag of fecal residue was removed from the processor, dated, and stowed for return to earth.

Each crewman had his own urine drawer at the base of the fecal/urine collector. Each drawer housed a blower unit, a centrifugal fluid/gas separator, and a collection bag. Airflow from the blower drew urine into the centrifuge, which separated the urine from the air by providing a force which substituted for gravity before it went into the bag. At the end of the 24-hour period, the crewman estimated his daily urine output. Every 24 hours, a crewman would withdraw a 120 ml sample and place it into a freezer for return to earth at the end of the mission.

APOLLO-SOYUZ

During the Apollo-Soyuz Test Project, the joint U.S.-Soviet space flight to test international rendezvous and docking techniques, American crewmen used the same waste management systems developed for the lunar program. This was because the same type of spacecraft, the Apollo command module, was used for this mission.

The Soyuz spacecraft used by the Russions was a rather crude craft compared to the Apollo spacecraft. It had very few comforts of home. According to the astronauts, the Soyuz waste system did not always do a proper job.

SPACE SHUTTLE

The system for disposing of human wastes is even more sophisticated on the space shuttle orbiter than it was on Skylab. However, medical samples are not normally taken, a function which complicated the Skylab system.

On the space shuttle, women flew as astronauts for the first time in the American space program. Consequently, the orbiter was designed to collect and process biowastes from both male and female crew members.

The orbiter's waste collection system has a set of controls that are used to configure the system for various modes of operation, namely: urine collection only, combined urine and feces collection, emesis collection, and combinations of those. The system consists of a commode, or waste collector, to handle solid waste, and a urinal assembly to handle fluids.

The waste collection system may be used in both zero gravity and in a one-g (earth) environment with the orbiter in the horizontal position.

The urinal is used by both males and females, with the user either holding the urinal while standing, or sitting on the commode with the urinal mounted to the waste collection system. A contoured cup with the urinal provides a good seal with the female crewmember's body.

During urination, an airflow draws the urine into a fan separator, which separates the waste water from the air. The fluid is forced along into a tube leading to the waste water storage tank. The air is drawn out of the chamber by a blower and returned to the orbiter cabin after being filtered to remove bacteria, dirt and odor.

The commode is also used for collecting both feces and emesis. It has a capacity for storing the equivalent of 210 person-days of vacuum-dried feces and toilet tissue. It may be used up to four times per hour, and may be used simutaneously with the urinal.

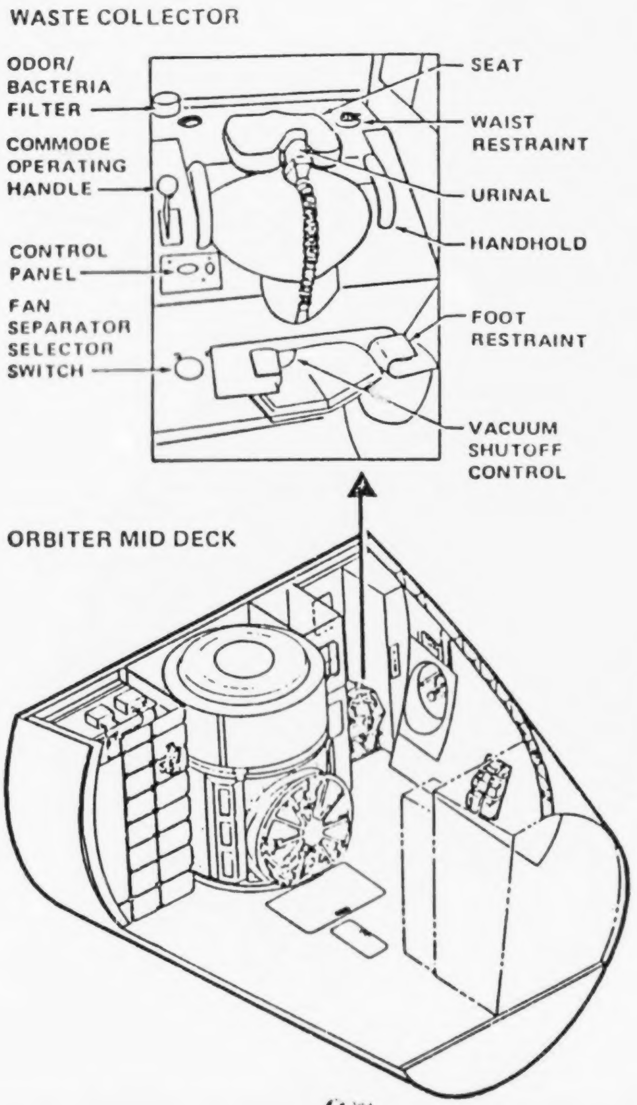
To operate the collector during defecation, the user positions self on the commode seat. Hand holds, foot restraints (used in conjunction with suction cup shoes), and waist restraints (similar to car seat-belts) help the user maintain a good seal with the seat. The crewmember used the equipment like a normal toilet, including tissue wipes. The tissue is disposed of in the commode.

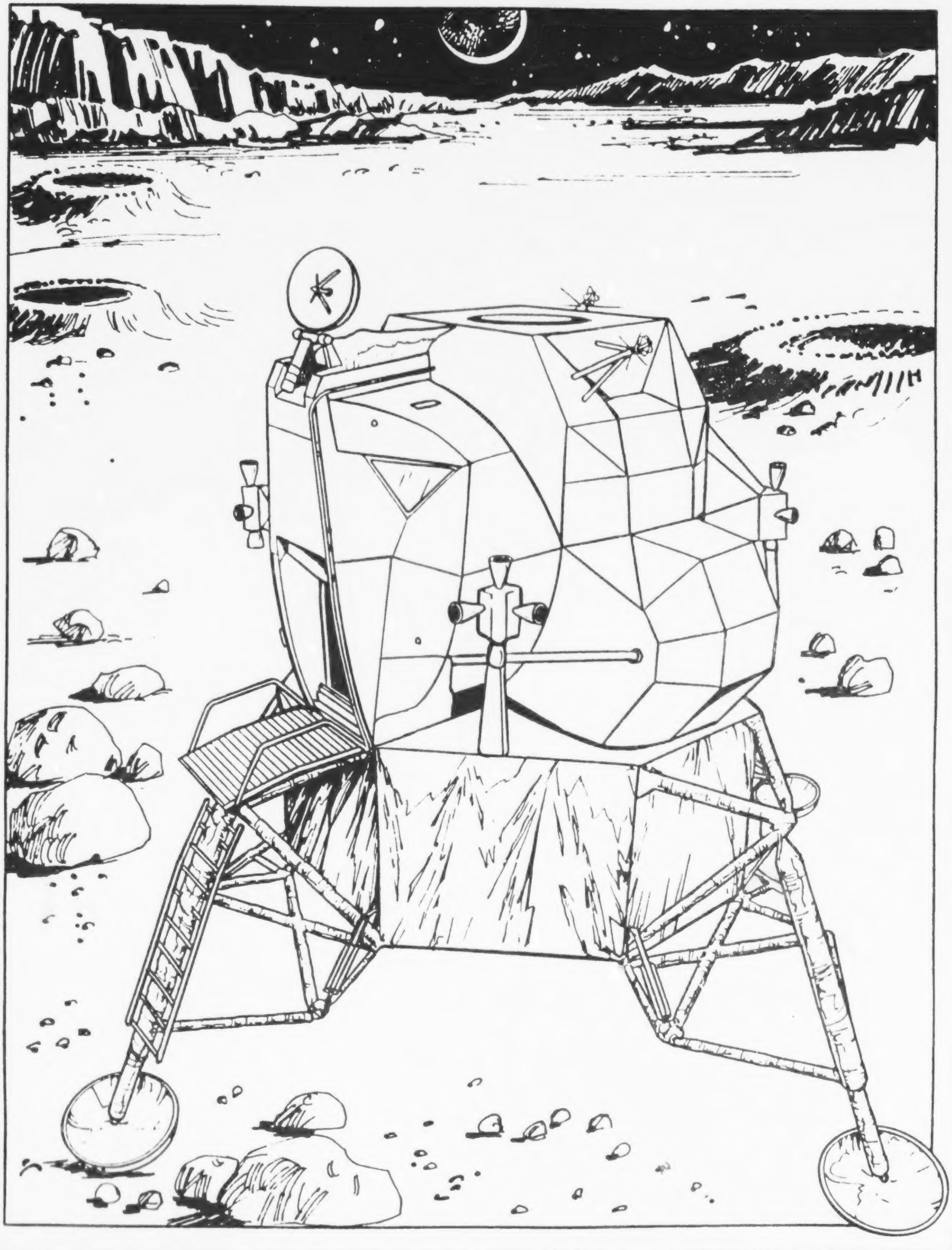
An airflow draws a solids/air mixture into the commode. A rotating slinger shreds the feces and flings it onto the commode inner wall, where it adheres in a thin layer. The tissue does not shred, but slides up and over the rotating tines, adheres to the inner walls, and is stored with the feces.

The commode is used in a slightly different manner for the disposal of used emesis collection bags. A bag containing vomitus is sealed with velcro, and deposited into the commode. The user changes the mode of operation so that the slinger rotates at a slower rate. The tines stay folded, and the bag has a clear passage. Air flow and the rotating slinger move it into the storage container.

The same type of bag may be used as a backup to the waste collection system for fecal collection. The bag is attached below the commode seat and expands into the commode volume. After use, the bag is released into the commode opening where air flow moves it into the storage area.

Everything stored in the waste collector -- feces, tissues, and fecal and emesis bags -- is subjected to vacuum drying in the collector and is returned to earth.


WASTE COLLECTOR
ODOR/ BACTERIA FILTER
COMMODE OPERATING HANDLE
CONTROL PANEL
FAN SEPARATOR SELECTOR SWITCH
SEAT
WAIST RESTRAINT
URINAL
HANDHOLD
FOOT RESTRAINT
VACUUM SHUTOFF CONTROL
ORBITER MID DECK



Read the description of the Waste Management Systems used in spaceflight, then answer the questions below.

1. What are three main requirements a waste management system must meet: ____________________, ____________________ and ______________.

2. On a Mercury mission only one form of human waste had to be handled. Name that form. _________________________. Why only one? ____

3. What is emesis? ____

4. On Gemini missions what was the shape of the urine bag used during launch? ____

5. On the Gemini missions, after urine was eliminated from the astronaut's body, what happened to it? ________________________________

6. On what missions were the first samples of urine collected for medical examination? ____

7. What type of bag was used on Gemini to collect the solid waste material? ____

8. How long were the Apollo missions? ______________________________

9. During extravehicular activities the Apollo astronauts wore a fecal conatinment system under the pressurized suits. It looked like a ________________________________.

10. Why was urine not dumped overboard the lunar module while it sat on the moon? ________________________________.

11. Why were body waste samples needed on Skylab? ____________ ________________________________.

12. How much urine was saved each day be each astronaut to be returned to earth for medical study? ________________________.

13. In Skylab where was the toilet located? ________________.

14. What type of waste management system was used by U.S. astronauts on the Apollo-Soyuz mission? ________________________.

15. The shuttle orbiter's waste management system was designed to accomodate both ____________ and ___________ crewmembers.

16. List the two basic units of the shuttle's waste management system. ____________________ and ____________________.

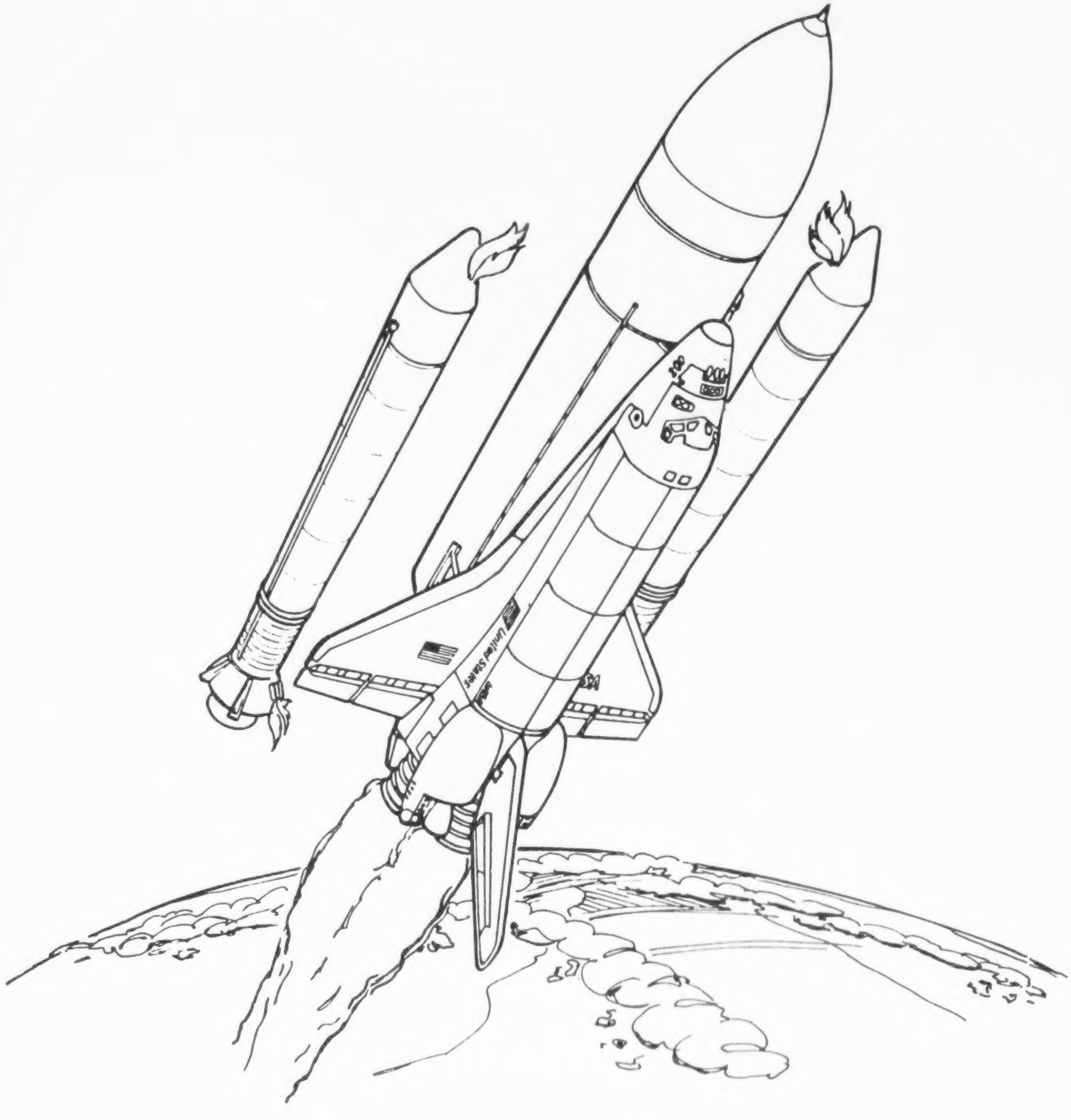
17. Can the shuttle's waste management system be used in an earth environment? ________________________________.

18. How many days of vacuum-dried feces and toilet tissue can the shuttle's system store? ______________________________.

19. How many times an hour can the shuttle's waste management system be used? ______________________________.

20. What is provided on the shuttle's commode to insure the user stays in contact with the commode's seat? __________________, __________________ and ______________________________.

21. Design your own waste management system for a spacecraft which would be operational for over a month. Include drawings and written descriptions.


United States

HUMAN SPACE FLIGHT LOG

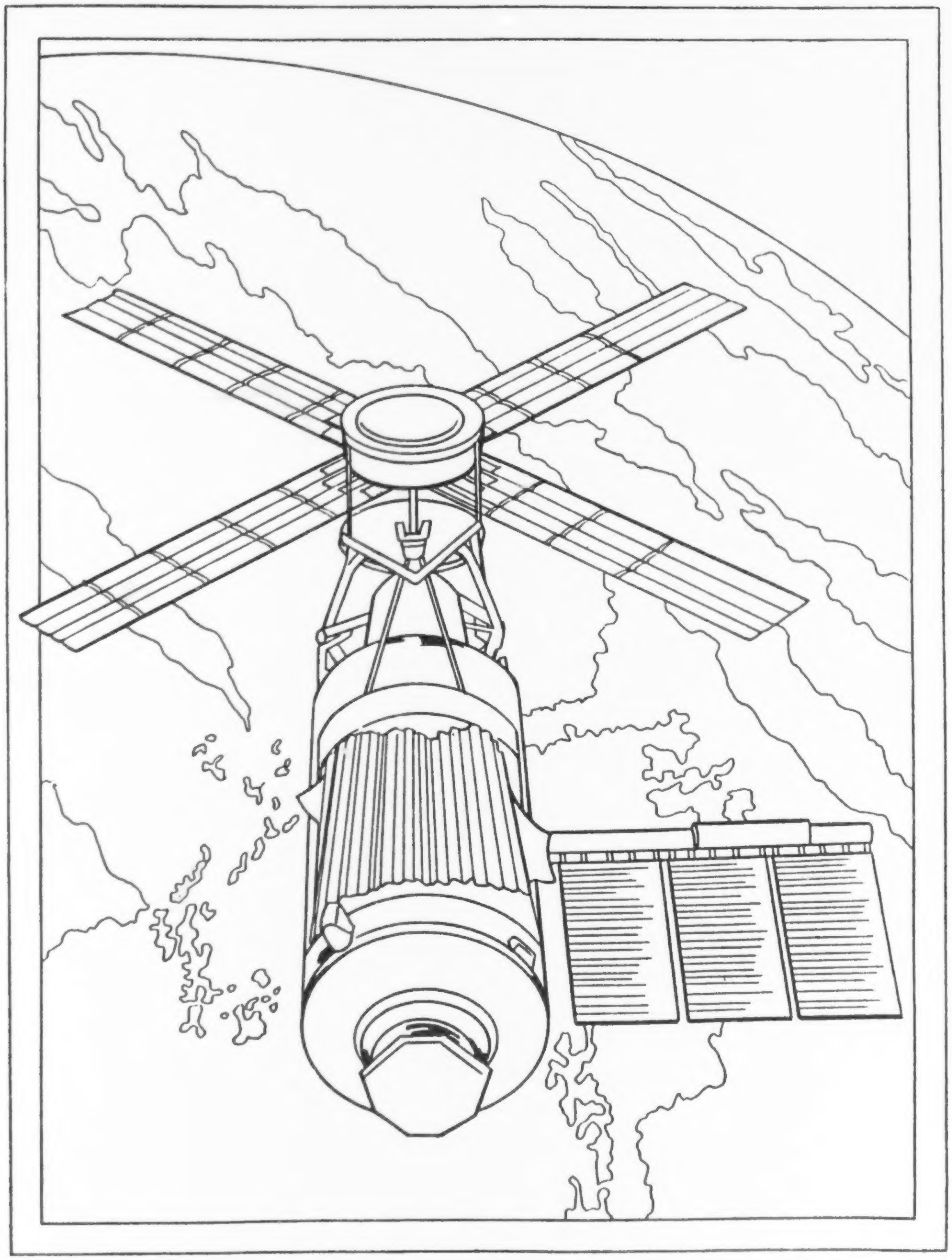
Mission	Crew	Date	Duration hr:min:sec	Remarks
Mercury-Redstone 3	Shepard	May 5, 1961	00:15:22	Suborbital flight--first American in space. USS Champlain, Atlantic recovery (A). Spacecraft call sign Freedom 7.
Mercury-Redstone 4	Grissom	July 21, 1961	00:15:37	Suborbital; successful flight but spacecraft sank, astronaut rescued. USS Randolph (A). Liberty Bell 7.
Mercury-Atlas 6	Glenn	Feb. 20, 1962	04:55:23	Three-orbit flight; first American in orbit; retropack retained when erroneous signal indicated heat shield possibly loose; capsule landed 40 miles uprange. USS NOA (A). Friendship 7.
Mercury-Atlas 7	Carpenter	May 24, 1962	04:56:05	Also three-orbit mission; yaw error at manual retrofire caused 250-mile landing overshoot. USS Pierce (A). Aurora 7.
Mercury-Atlas 8	Schirra	Oct. 3, 1962	09:13:11	Six-orbit flight; capsule landed 4.5 miles from recovery ship USS Kearsarge, Pacific (P). Sigma 7.
Mercury-Atlas 9	Cooper	May 15-16, 1963	34:19:49	Twenty-two orbits to evaluate effects on man of 1 day in space; landed 4.5 miles from USS Kearsarge (P). Faith 7.
Gemini-Titan III	Grissom, Young	March 23, 1965	04:53:00	Three-orbit demonstration of the spacecraft; maneuver over Texas on first pass changed orbital path of a manned spacecraft for first time; landed 50 miles uprange. USS Intrepid (A). Molly Brown (only Gemini named).
Gemini-Titan IV	McDivitt, White	June 3-7, 1965	97:56:11	Four-day flight with White first American to walk in space in 20-minute extravehicular activity (hatch open 36 minutes); after 62 revolutions of earth, landed 50 miles uprange from USS Wasp (A).
Gemini-Titan V	Cooper, Conrad	Aug. 21-29,1965	190:55:14	First use of fuel cells for electric power; evaluated guidance and navigation system for future rendezvous missions; incorrect navigation coordinates from ground control resulted in landing 90 miles short; 120 revolutions. USS Lake Champlain (A).
Gemini-Titan VII	Borman, Lovell	Dec. 4-18, 1965	330:35:31	Longest-duration Gemini flight; provided rendezvous target for Gemini VI-A; crew flew portions of mission in shirtsleeves for first time; 206 revolutions; landed 6.4 miles from target. USS Wasp (A).

Gemini-Titan VI-A	Schirra, Stafford	Dec. 15-16, 1965	25:51:24	Rescheduled to rendezvous with Gemini VII after original target Agena failed to orbit; VI-A launch postponed 3 days when launch vehicle engines automatically shut down 1.2 seconds after ignition; completed first space rendezvous; after 16 revolutions, landed within 7 miles of target to initiate series of pinpoint landings by Gemini spacecraft. USS Wasp (A).
Gemini-Titan VIII	Armstrong, Scott	March 16, 1966	10:41:26	First docking of one space vehicle with another; about 27 minutes after docking, Gemini-Agena combination began to yaw and roll at increasing rates; emergency procedures included undocking, deactivation of malfunctioning control system, activation of reentry control system; mission was terminated and, midway through 7th revolution, spacecraft landed 1.1 miles from planned landing point in secondary recovery area in western Pacific; destroyer USS Mason picked up crew 3 hours later.
Gemini-Titan IX-A	Stafford, Cernan	June 3-6, 1966	72:21:00	Rescheduled to rendezvous and dock with augmented target docking adapter after original target Agena failed to orbit; ATDA shroud did not completely separate, making docking impossible; three different types of rendezvous were completed; Cernan carried out 2 hours 7 minutes of EVA; 44 revolutions; 0.38 miles from target. USS Wasp (A).
Gemini-Titan X	Young, Collins	July 18-21, 1966	70:46:39	First use of Agena target vehicle's propulsion systems; spacecraft also rendezvoused with Gemini VIII target vehicle; Collins had 49 minute EVA standing in hatch, 39-minute EVA to retrieve experiment from Agena VIII; 43 revs; 3.4 miles, USS Guadalcanal (A).
Gemini-Titan XI	Conrad, Gordon	Sept.12-15,1966	71:17:08	Gemini record altitude (739.2 miles) reached using Agena propulsion after first-revolution rendezvous and docking; Gordon fastened Agena-anchored tether to Gemini docking bar, and spacecraft later made two revolutions of earth in tethered configuration; Gordon 33-minute EVA and 2-hour 5-minute standup EVA; 44 revs; 1.5 miles, USS Guam (A).

Gemini-Titan XII	Lovell, Aldrin	Nov.11-15, 1966	94:34:31	Final Gemini flight; Aldrin logged 2-hour 29-minute standup EVA, 55-minute standup EVA, and 2-hour 6-minute EVA for Gemini record total of 5 hours 30 minutes of EVA; 59 revs, 2.6 miles, USS Wasp (A).
Apollo-Saturn 7	Schirra, Eisele, Cunningham	Oct. 11-22, 1968	260:09:03	First manned flight of Apollo spacecraft command-service module only, 163 revs.; USS Essex (A). All Apollo spacecraft splashed down within 10 miles of predicted landing point.
Apollo-Saturn 8	Borman, Lovell, Anders	Dec. 21-27, 1968	147:00:42	First flight to moon (command-service module only, views of lunar surface televised to earth; 10 revs of moon; USS Yorktown (P).
Apollo-Saturn 9	McDivitt, Scott, Schweickart	March 3-13, 1969	241:00:54	First manned flight of lunar module; spacecraft call signs for communications identification when undocked: CSM "Gumdrop" and LM "Spider"; Schweickart 37-minute EVA from LM; 151 revs; USS Guadalcanal (A).
Apollo-Saturn 10	Stafford, Young, Cernan	May 18-26, 1969	192:03:23	First lunar module orbit of moon; call signs Charlie Brown and Snoopy; 31 revs of moon (4 revs by undocked LM); USS Princton (P).
Apollo-Saturn 11	Armstrong, Collins, Aldrin	July 16-24, 1969	195:18:35	First lunar landing; call signs Columbia and Eagle; lunar stay time 21 hours 36 minutes 21 seconds, Armstrong and Aldrin EVA (hatch open to hatch close) 2 hours 31 minutes 40 seconds, lunar surface samples 43.5 pounds; 30 revs; USS Hornet (P).
Apollo-Saturn 12	Conrad, Gordon, Bean	Nov. 14-24, 1969	244:36:25	Yankee Clipper and Intrepid; stay time 31 hours 31 minutes, Conrad and Bean EVAs 3 hours 56 minutes and 3 hours 49 minutes, lunar samples 74.7 pounds plus parts from Surveyor 3 unmanned spacecraft; 45 revs; USS Hornet (P).
Apollo-Saturn 13	Lovell, Swigert, Haise	Apr. 11-17, 1970	142:54:41	Odyssey and Aquarius; mission aborted after service module oxygen tank ruptured; using lunar module oxygen and power until just before reentry, crew returned safely to earth; USS Iwo Jima (P).
Apollo-Saturn 14	Shepard, Roosa, Mitchell	Jan. 31-Feb. 9, 1971	216:01:57	Kitty Hawk and Antares; stay time 33:31, Shepard and Mitchell EVAs 4:48 and 4:35, samples 96 pounds; 34 revs; USS New Orleans (P).

Apollo-Saturn 15	Scott, Worden, Irwin	July 26-Aug. 7, 1971	295:11:53	Endeavour and Falcon; first use of lunar roving vehicle; stay time 66:55; Scott standup EVA 33 minutes, Scott and Irwin EVAs 6:33, 7:12, and 4:50, Worden trans-earth EVA 38 min, samples 170 pounds; 74 revs; USS Okinawa (P).
Apollo-Saturn 16	Young, Mattingly, Duke	Apr. 16-27, 1972	265:51:05	Casper and Orion; stay time 71:02; Young and Duke EVAs 7:11, 7:23 and 5:40, Mattingly trans-earth EVA 1:24, samples 213 pounds; 64 revs: USS Ticonderoga (P).
Apollo-Saturn 17	Cernan, Evans, Schmitt	Dec. 7-19, 1972	301:51:59	America and Challenger; stay time 75:00; Cernan and Schmitt EVAs 7:12, 7:37 and 7:15, Evans trans-earth EVA 1:06, samples 243 pounds; 75 revs; USS Ticonderoga (P).
Skylab 1	Unmanned	Launched May 14, 1973		100-ton space station visited by three crews. Re-entered atmosphere 7-11-79 on orbit 34,981.
Skylab 2	Conrad, Weitz, Kerwin	May 25-June 22, 1973	28 days:49 min:49 sec.	Repaired Skylab; 404 orbits; 392 experiment hours; three EVAs total 5 hrs. 34 min. USS Ticonderoga (P).
Skylab 3	Bean, Lousma, Garriott	July 28-Sept.25, 1973	59 days: 11 hrs: 9 min:4 sec.	Performance maintenance, 858 orbits; 1,081 experiment hours; three EVAs total 13 hrs.42 min. USS New Orleans (P).
Skylab 4	Carr, Pogue, Gibson	Nov. 16, 1973-Feb. 8, 1974	84 days: 1 hr:15 min: 31 sec.	Observed Comet Kohoutek; 1,214 orbits; 1,563 experiment hours; four EVAs total 22 hrs.25 min. USS New Orleans (P).
Apollo-Soyuz Test Project	Stafford, Brand, Slayton	July 15-24, 1975	9 days:1 hr: 28 min: 24 sec.	Apollo docked with Soviet Soyuz spacecraft July 17; separated July 19. USS New Orleans (P).
STS-1 (Columbia)	Commander: Young; Pilot: Crippen	April 12-14, 1981	54:20:52 36.5 orbits	First orbital flight of space shuttle; first NASA space mission touchdown on land; first use of solid fuel boosters (SRBs) for manned space flight; first use of heat tiles; first maiden flight of a space vehicle carrying human crew.
STS-2 (Columbia)	Commander: Engle; Pilot: Truly	Nov. 12-14, 1981	54:13:12 36 orbits	First reuse of manned vehicle previously flown in space; first test in space of remote manipulator system (RMS); first experiment payload (OSTA-1); mission reduced from 5 days when one of three fuel cells failed.
STS-3 (Columbia)	Commander: Lousma; Pilot: Fullerton	March 22-30, 1982	192 hrs: 5 min. 129 orbits	First use of contingency landing site; RMS used to move cargo in in space; flew OSS-1, other experiments, including one designed by a student. Problems: crew space sickness, malfunctioning toilet. New mission record, 8 days 5 minutes.

STS-4 (Columbia)	Commander: Mattingly; Pilot: Hartsfield	June 27-July 4, 1982	169 hrs: 9 min. 112 orbits	First landing by Orbiter on a concrete runway (Edwards AFB). Mission goals: further test the flying, handling and operating characteristics of the orbiter, to perform more exercises with the manipulator arm. First Getaway Special carried aboard; series of 9 experiments prepared by students; performed cloud-top lightening survey. Problem: loss of two solid rocket booster castings.
STS-5 (Columbia)	Commander: Brand; Pilot: Overmyer; Mission Specialists: Allen, Lenoir	Nov. 11-16, 1982	122 hrs: 14 min. 81 orbits	First operational flight for the shuttle; first launch of 2 commercial communications satellites (SBS-3 and Anik C-3). First four-member crew; 3 SSIP experiments conconducted for students. Problem: EVA canceled due to malfunction of ventilator motor in one suit, a pressure regulator in the other.
STS-6 (Challenger)	Commander: Weitz; Pilot: Bobko; Mis. Specs.: Peterson, Musgrove	April 4-9, 1983	120 hrs: 25 min. 80 orbits	First launch of Orbiter Challenger; first spacewalk (4 hrs. 17 min.) using new spacesuits. Launch of the first Tracking and Data Relay (TDRS) satellite; three getaway specials flown in cargo bay. Problem: orininally scheduled launch was postponed twice, once for a hydrogen gas leak, second for payload contamination caused by a severe storm at the pad.
STS-7 (Challenger)	Commander: Crippen; Pilot: Hauck; Mis. Specs.: Fabian, Ride, Thagard	June 18-24, 1983	146 hrs: 24 min. 97 orbits	First STS launch with crew of five; first spaceflight of an American woman; 7 Getaway Special cannisters carried in cargo bay; payload of 2 commercial communication satellites (Anik 2 and Palapa-B); conducted medical tests in orbit on the problem of Space Adaptation Syndrome; shuttle pallet satellite (SPAS-01) mounted in cargo bay released into space by the arm and it operated under its own power for several hours. Problem: STS-7 was scheduled to land at KSC, but rainy weather forced a landing at Edwards AFB.
STS-8 (Challenger)	Commander: Truly Pilot: Brandenstein Mis. Specs.: Gardner, Bluford, Thornton	Aug. 30- Sept. 5, 1983	145 hrs: 9 min. 96 orbits	First night launch of a space shuttle; first night landing of a space shuttle; first spaceflight by an American black astronaut. Continued medical studies; launch of INSAT-1B satellite; 12 Getaway Special cannisters carried; an SSIP experiment flown on board. No problems.
STS-9 (Columbia)	Commander: Young Pilot: Shaw Mis. Specs.: Garriott, Parker Payload Specs: Merbold, Lichtenberg	Nov. 28-Dec.8, 1983	247 hrs: 47 min. 166 orbits	Firsts: six person crew; flight of Spacelab; payload specialists in crew; flight of a European (Merbold) aboard the Shuttle; non-NASA American astronaut (Lichtenberg). STS-9 verified the ability of principal investigators at the Payload Operation Control Center to interact with crew in orbit on a "live" basis. Problems: landing delayed 5-7 hrs. due to malfunction of two of the Orbiter's general purpose computers and one inertial measurement unit.



"WHO AM I?"

4 R	9 A	6 K	8 S	10 C	5 G	7 S
9 R	6 E	8 T	10 U	9 M	7 H	9 S
8 A	6 R	4 I	5 L	7 E	9 T	10 N
9 R	10 N	5 E	7 P	6 W	10 I	8 F
9 O	5 N	7 A	8 F	4 D	10 N	9 N
5 N	7 R	8 O	10 G	9 G	6 I	10 H
7 D	10 A	10 M	8 R	6 N	8 D	4 E

Find out who the famous astronaut is. Count the number of letters in your name. If you have less than 4 letters, add 2. If you name has exactly 4 letters do not add or subtract -- use that number, 4. If you have more than 10 letters in your name subtract 3 and use that number. Place your number in the box in the upper right hand corner of the page. Follow the chart from left to right and work down, starting in the upper left corner of the chart. List all the letters that go with your number and discover your famous astronaut.

FAMOUS ASTRONAUTS

Use the Human Spaceflight Log (pages 63-67) to help answer the following questions.

1. What is the name of "your" famous astronaut?____________________

2. What was the first mission he/she flew on?____________________

3. Did he/she fly on more than one?__________ If so, list other missions flown.____

4. Were there any "firsts" on this astronaut's mission?_____________ List.____

5. On what date did "your" astronaut fly during his/her first flight?
____

6. If there was a recovery ship used on "your" astronaut's flight, give its name.____

7. Did "your" astronaut walk on the moon?__________________________

8. What is the total amount of time "your" astronaut was in space?
____

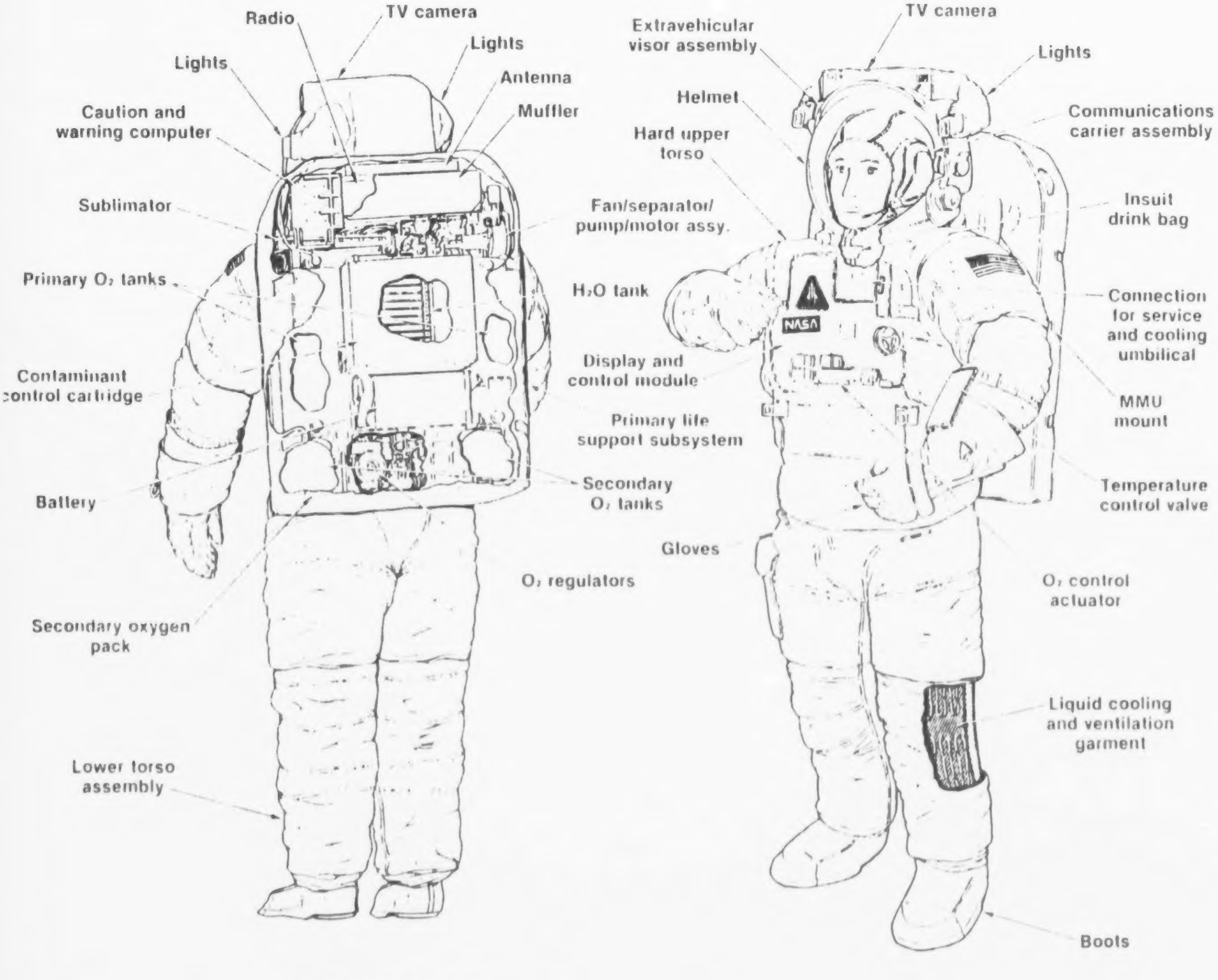
9. When "your" astronaut returned from his/her space mission, did the landing occur on land or in the ocean?____________________________

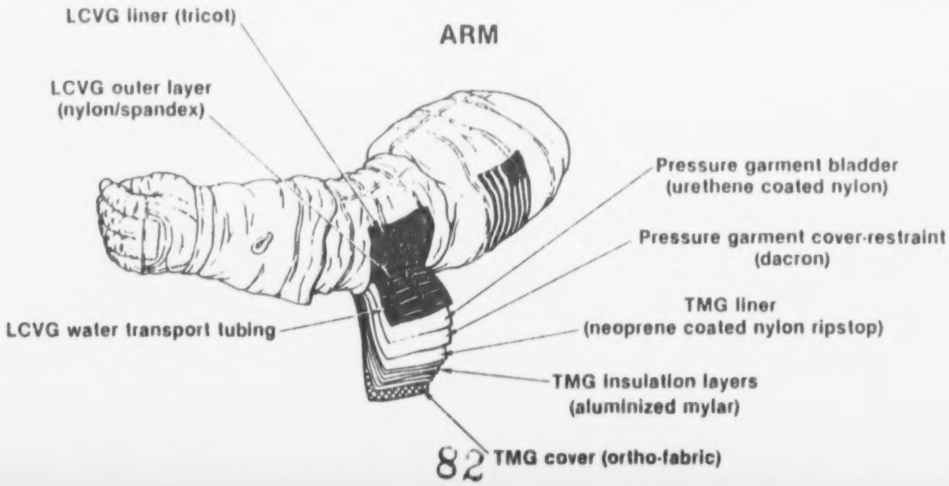
10. Name the type of rocket used on "your" astronaut's first flight.

____

BONUS POINTS: Write a paragraph about "your" astronaut. Include how you think he/she feels about being an astronauat.

EXTRAVEHICULAR MOBILITY UNIT


Radio
TV camera
Lights
Lights
Antenna
Caution and warning computer
Muffler
Sublimator
Fan/separator/ pump/motor assy.
Primary O_2 tanks
H_2O tank
Contaminant control cartridge
Display and control module
Primary life support subsystem
Battery
Secondary O_2 tanks
O_2 regulators
Secondary oxygen pack
Lower torso assembly
TV camera
Extravehicular visor assembly
Lights
Helmet
Communications carrier assembly
Hard upper torso
Insuit drink bag
Connection for service and cooling umbilical
MMU mount
Temperature control valve
Gloves
O_2 control actuator
Liquid cooling and ventilation garment
Boots
NASA


ARM
LCVG liner (tricot)
LCVG outer layer (nylon/spandex)
Pressure garment bladder (urethene coated nylon)
Pressure garment cover-restraint (dacron)
LCVG water transport tubing
TMG liner (neoprene coated nylon ripstop)
TMG insulation layers (aluminized mylar)
TMG cover (ortho-fabric)

HUMAN REACTION TIME -- Part 1

During a space flight astronauts are required to be able to respond quickly to any given situation. Unexpected problems may arise during a space flight that require a rapid response to the problem. The faster the reaction time of an astronaut and the crew, the better chance they will have in dealing with a given situation.

Students can measure their reaction time by using the reaction time card (following page) in this manner:

1. Divide the class into teams of two students each. While one does the activity, the other student times his/her responses.
2. Have one student start with a finger on square one and touch each square in numerical order. The other student should record the time. Then have the same student touch the squares in reverse order. Record the time again.
3. Students should then reverse roles.
4. Allow the students to do the activity for 2 or 3 days in a row to see if their reaction time improves.
5. Compare results of boys versus girls, age groups, left-handed versus right-handed students, etc., by recording group averages on the blackboard.
6. Allow students to put their own symbols in the blank squares. They might try to devise an ordering system which is faster than numbers.

10 seconds	slow
9 seconds	average
7 seconds	very good
5 seconds	excellent

REACTION TIME CARD

TIME _______ SECONDS

8	11	5	2
1	12	9	7
6	3	10	4

TIME _______ SECONDS

TIME _______ SECONDS

4	11	7	1
6	9	10	5
2	8	12	3

TIME _______ SECONDS

Numerical

Day 1 _______ Time

Day 2 _______ Time

Day 3 _______ Time

Reverse

Day 1 _______ Time

Day 2 _______ Time

Day 3 _______ Time

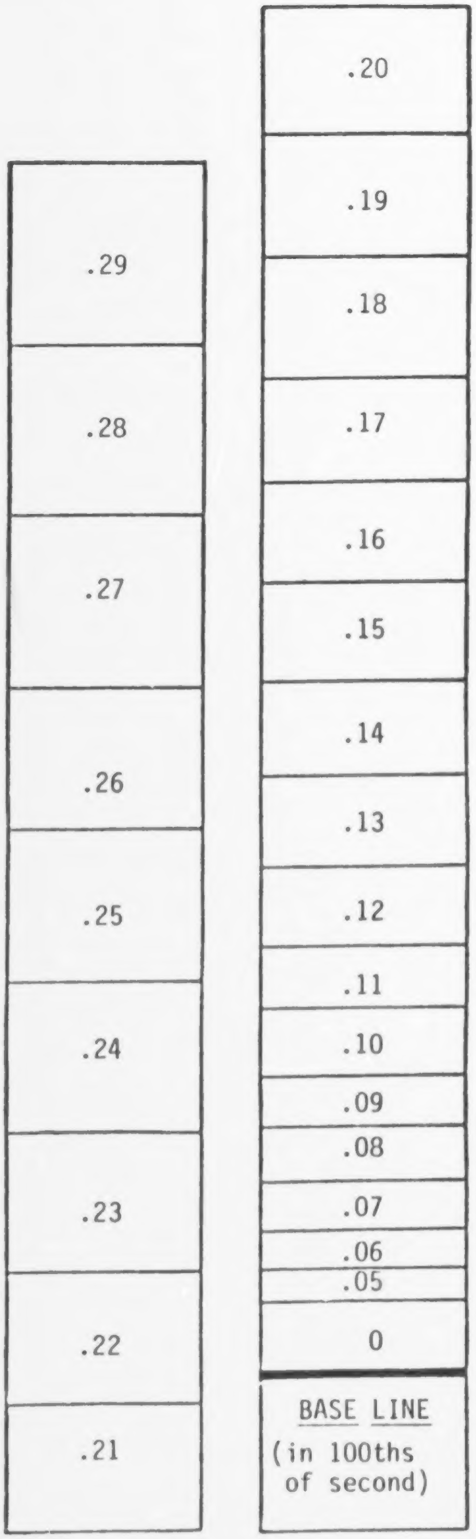
Note: Try with the other hand to see if there is a difference in reaction time.

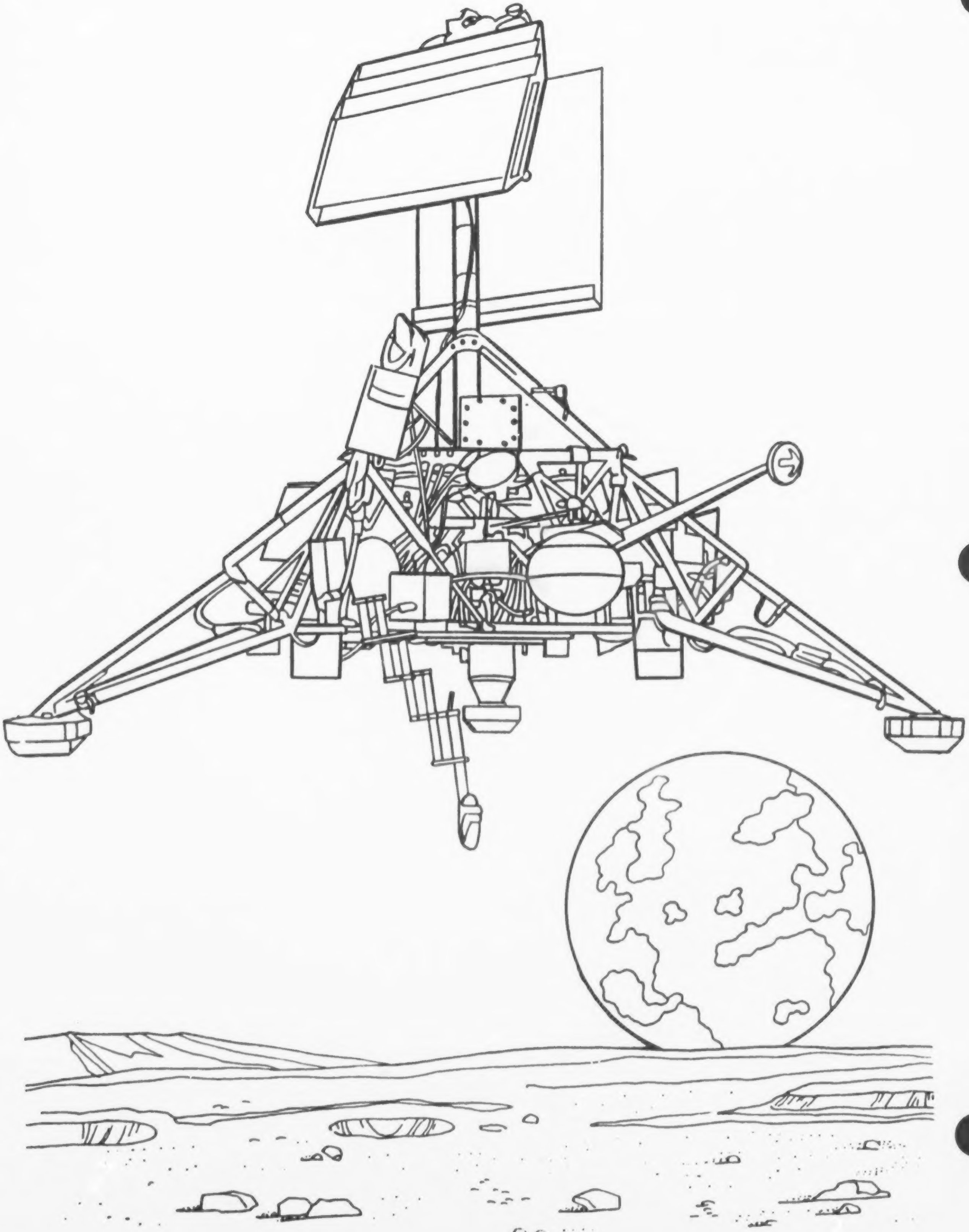
HUMAN REACTION TIME--PART 2

Another method of measuring a person's reaction time is with the scale included here. Duplicate the scale and paste it over a meterstick. The heavy black line should be taped at bottom, then paste the other strip at the top of the first one. The markings are in 1/100ths of a second.

1. Divide class into teams, 3 or 4 in each team.
2. Taking turns, have one student rest his/her right or left forearm on table or desk top with hand extended over the edge. Have another team member drop the meterstick so that it passes vertically between subject's index finger and thumb, so that he/she may catch it after it starts to fall.
3. The student should start with thumb and index finger apart the width of the meterstick. This way a standard width is used by all persons.
4. Start by placing meterstick at zero between student's thumb and index finger. Release stick and have student catch it.
5. Record the number where student's fingers grasp the stick. Note: if stick is missed the score is 29, not zero.
6. Have each student perform the test 3 times and take an average.
7. Try another way. Tape a child's small cricket clicker to top of meterstick. Blindfold student and have him/her catch the stick with eyes closed, responding to the "click" of the clicker.
8. Repeat 3 times and take an average.

Have students record their averages, both sight and sound. Is there a difference? Does everyone have the same reaction time?





"A SOFT LANDING?"

Landing a spacecraft with scientific instruments or astronauts aboard on the moon or another planet is unlike landing on the Earth. Since those bodies have no atmosphere, or a very thin one, landing will be difficult. Parachutes cannot be used because no air, or very little air, is available to operate them. Also, the pull of gravity by each of the bodies is different. However, for this activity we will use the earth's gravitational pull.

An activity to illustrate this problem is an EGG DROP.

1. Discuss with class the problems of landing in a thin atmosphere.
2. Class could be divided into cooperative groups of 2 or 3 students.
3. Each group should be given a raw egg, which should first be placed in a ziplock plastic bag to eliminate mess in the event of an unsuccessful landing. The raw egg is to be packaged in a container approximately 6"x 6" with no outside fins to assist in the descent of the egg.
4. If possible, secure help from local airport people. Have a pilot drop the eggs from the plane at 500 feet altitude over the school grounds or a nearby open area.
5. If a plane is unavailable, use a different approach. Give each student a raw egg, a plastic bag, and 2 full pages from newspaper. Students are to place the egg in the bag. The egg should be dropped from a second or third story window, or the roof of a one-story building, using only the 2 pages of newspaper to control the descent. The students may use the paper in any way they wish.
6. Allow a few days for student to research their project.
7. Any cracked or broken egg will be considered a failure in protection of the student's payload.
8. After the experiment discuss with students better ways of packaging their payload.
9. Check the library to see what NASA has used, and also what is considered a safe landing speed.
10. Ask students what types of problems one would have landing a payload on Venus, Jupiter or other planets.

NOTE: Another variation of the Egg Drop activity is to assign it as a project (or make it optional for extra credit) to be done together with a parent or guardian at home. This is a way to involve parents in learning. Parents or other helpers could be invited to school on "drop day".

EXERCISING FOR SPACEFLIGHT

It is necessary for astronauts traveling in space to maintain good physical fitness. Due to limited space in the cabin, activities to maintain good physical fitness must be designed for these areas.

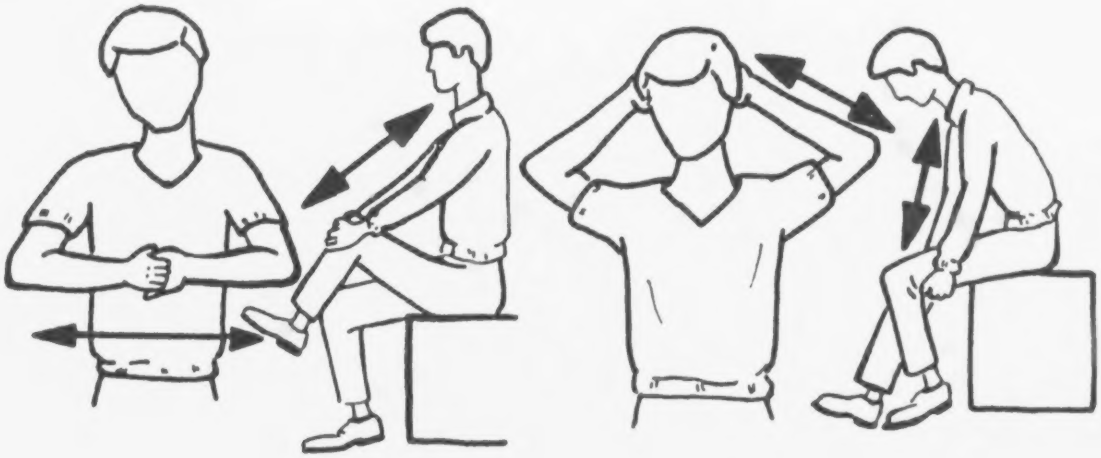
To simulate exercises done by the astronauts while in flight, try the following basic isometrics:

1. Grasp right hand in left hand and pull in opposite directions while hands are held together for 5 seconds, 10 seconds, and 20 seconds.

2. Grasp left leg at the knee with clasped hands. Pull leg toward chest 10 times. Repeat procedure with other leg.

3. Clasp hands behind head. Pull in opposite directions.

4. In a seated position, clasp hands under legs. Pull in opposite direction.



PULSE RATE TEST

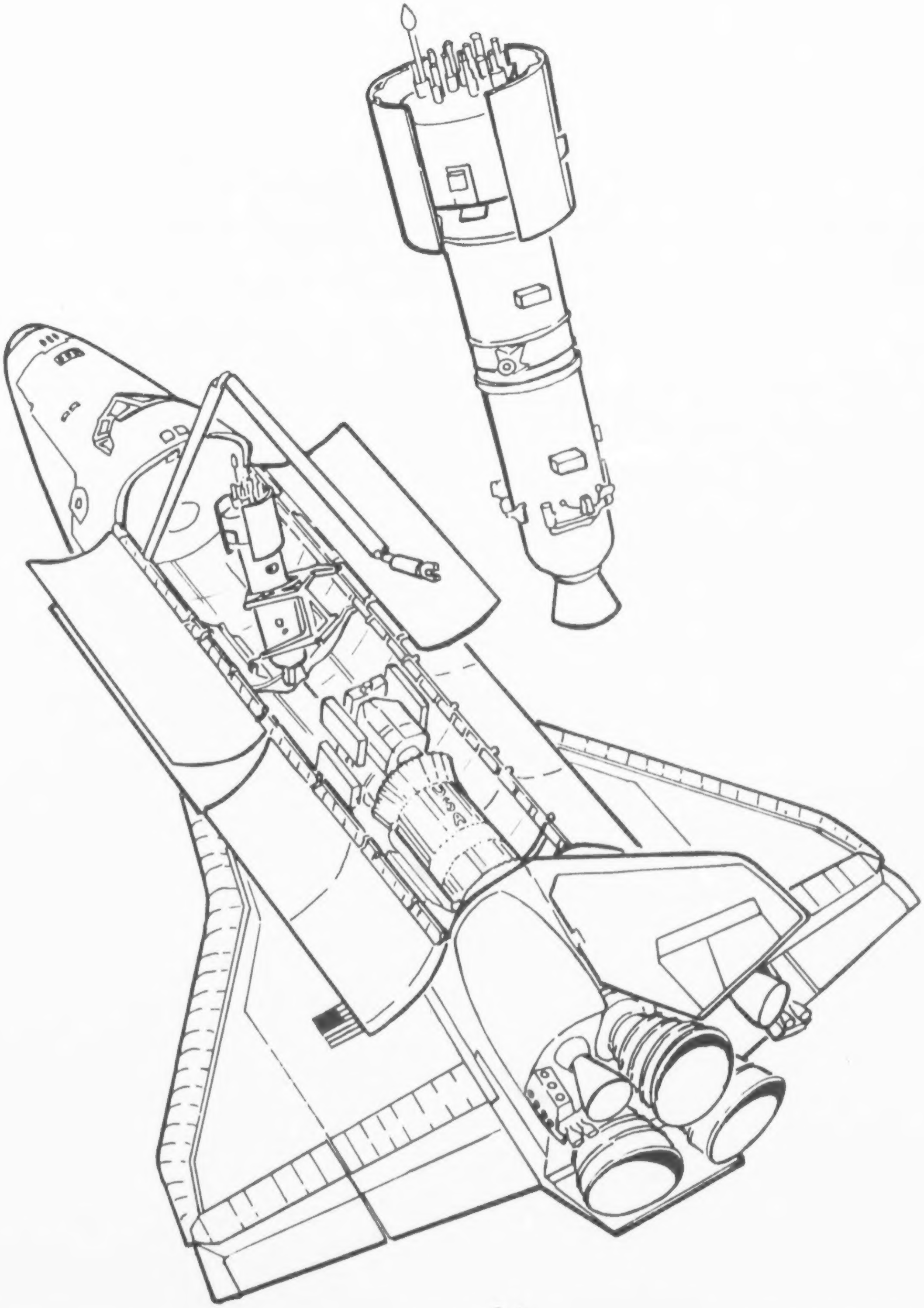
Astronauts must be in good physical condition to fly in space.

To give students an understanding of some of the activities astronauts use to stay fit, let them check their pulse rate under various conditions. In addition to locating a step approximately 18 inches high, you will need the following materials; chart for recording pulse rate (see below) and pencils.

1. Divide the class into teams. Have students take their partner's pulse rate at rest, and record it for future reference. The teacher may need to assist the students in the beginning so the proper technique is used when the pulse rate is taken.
2. Have students step up onto the step and down again at a rapid rate for 2 or 3 minutes -- approximately 20 times.
3. Have students take their partner's pulse rate again after the exercise; record and compare to pulse rate at rest.
4. Wait 3 minutes; again take pulse and record it. Repeat after 5 minutes. Compare to the previous pulse rates.

PULSE RATE CHART

Name	At rest	Immediately following exercise	3 min. after exercise	5 min. after exercise
1				
2				
3				
4				
5				
6				


USA

CODED MESSAGES

During a spaceflight a large quantity of data has to be transmitted back to earth at a high speed. To speed up the flow of data, it is easier to send this information in a coded system.

The statements below are in code. In this code, the number for A is 11 because it is in the first row, first column; for K, 25 (row 2, column 5); and N, 33. Note that since I and J are together, the other letters in a word using I or J will be the clue as to which letter to use.

	1	2	3	4	5
1	A	B	C	D	E
2	F	G	H	I/J	K
3	L	M	N	O	P
4	Q	R	S	T	U
5	V	W	X	Y	Z

42 45 43 43 24 11 33   13 34 43 32 34 33 11 45 44   54 45 42 24

_ _ _ _ _ _ _   _ _ _ _ _ _ _ _ _   _ _ _ _

22 11 22 11 42 24 33   12 15 13 11 32 15   44 23 15   21 24 42 43 44

_ _ _ _ _ _ _   _ _ _ _ _ _   _ _ _   _ _ _ _ _

35 15 42 43 34 33   24 33   43 35 11 13 15.   11 31 11 33

_ _ _ _ _ _   _ _   _ _ _ _ _.   _ _ _ _

43 23 15 35 11 42 14   52 11 43   44 23 15   21 24 42 43 44

_ _ _ _ _ _ _   _ _ _   _ _ _   _ _ _ _ _

11 32 15 42 24 13 11 33   24 33   43 35 11 13 15.   15 14

_ _ _ _ _ _ _ _   _ _   _ _ _ _ _.   _ _

52 23 24 44 15   52 11 43   44 23 15   21 24 42 43 44

_ _ _ _ _   _ _ _   _ _ _   _ _ _ _ _

35 15 42 43 34 33   44 34   14 34   11   43 35 11 13 15   52 11 31 25

___ ___ ___ ___ ___ ___   ___ ___   ___ ___   ___   ___ ___ ___ ___ ___   ___ ___ ___ ___.

23 11 42 42 24 43 34 33   43 13 23 32 24 44 44   52 11 43   44 23 15

___ ___ ___ ___ ___ ___ ___ ___   ___ ___ ___ ___ ___ ___ ___   ___ ___ ___   ___ ___ ___

31 11 43 44   35 15 42 43 34 33   44 34   52 11 31 25   34 33

___ ___ ___ ___   ___ ___ ___ ___ ___ ___   ___ ___   ___ ___ ___ ___   ___ ___

44 23 15   32 34 34 33   31 24 43 44   12 15 31 34 52   44 23 15

___ ___ ___   ___ ___ ___ ___.   ___ ___ ___ ___   ___ ___ ___ ___ ___   ___ ___ ___

14 11 44 15   11 33 14   32 24 43 43 24 34 33   21 34 42   15 11 13 23

___ ___ ___ ___   ___ ___ ___   ___ ___ ___ ___ ___ ___ ___   ___ ___ ___   ___ ___ ___ ___

34 21   44 23 15 43 15   35 15 34 35 31 15

___ ___   ___ ___ ___ ___ ___   ___ ___ ___ ___ ___ ___.

____

____

____

____

1. Write a message below, then encode it into a number code on a separate piece of paper. Give it to a friend to decode.

____

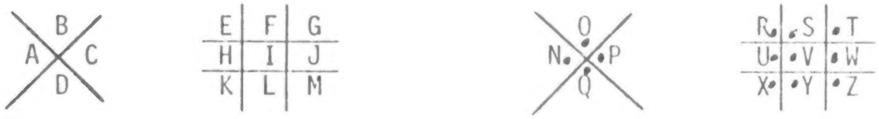
____

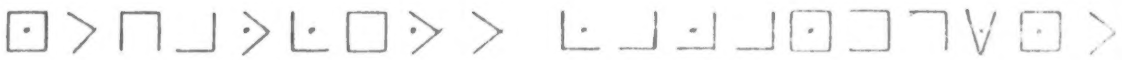
____

2. Invent a new code system of your own and write a message using it. See if a friend can "break" your code.

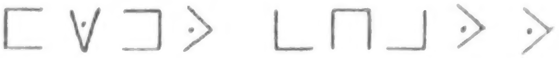
SPACE TRAVELERS

Below are the coded names of famous space travelers. To find out their names, solve the code by substituting a letter for each shape. Then, in the space provided on the next page, tell something unique about each one.

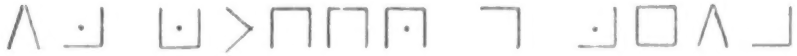

A B C D
E F G
H I J
K L M
N O P Q
R S T
U V W
X Y Z



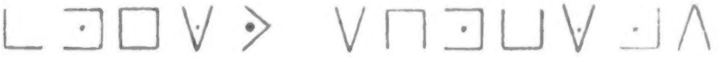
1. _ _ _ _ _ _ _ _ _   _ _ _ _ _ _ _ _ _ _



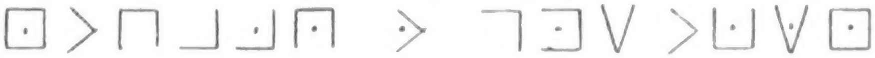
2. _ _ _ _   _ _ _ _ _



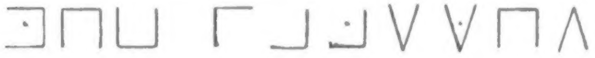
3. _ _   _ _ _ _ _   _   _ _ _ _



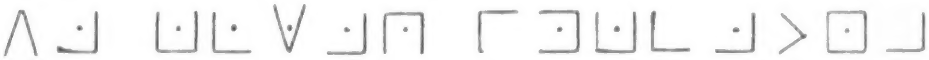
4. _ _ _ _ _   _ _ _ _ _ _ _



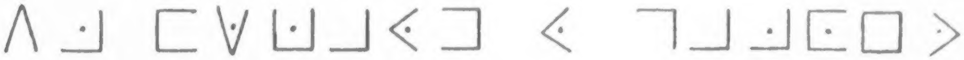
5. _ _ _ _ _ _   _   _ _ _ _ _ _ _



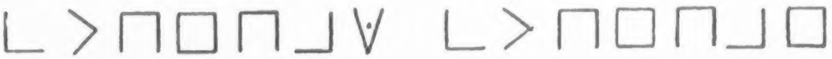
6. _ _ _   _ _ _ _ _ _ _



7. _ _   _ _ _ _ _ _   _ _ _ _ _ _ _ _



8. _ _   _ _ _ _ _ _   _   _ _ _ _ _ _



9. _ _ _ _ _ _ _   _ _ _ _ _ _ _

1. ______________________________

____

2. ______________________________

____

3. ______________________________

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4. ______________________________

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5. ______________________________

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6. ______________________________

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7. ______________________________

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8. ______________________________

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9. ______________________________

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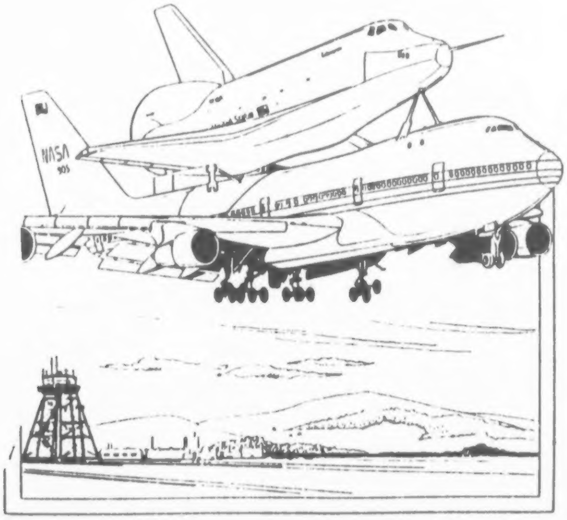


METRIC CONVERSION

The statements below relate to space flight. In the blanks provided, convert all numbers to metric.

1. The Shuttle Orbiter is 122 feet (________________) long.

2. The Shuttle Orbiter can carry up to 65,000 pounds (______________) of payload into space.

3. The Saturn V rocket developes 7.5 million pounds (_______________) of thrust at liftoff.

4. Satellites in geostationary orbits are placed 22,000 miles (____________________) above the earth.

5. The X-15 rocket engine generated 57,000 pounds (_________________) of thrust.

6. An Apollo Command module is 10 feet 7 inches (_____________) high.

7. A Saturn V rocket at liftoff weighs 6,384,000 pounds (__________).

8. The first successful probe of another planet occured on Dec. 14, 1962, when Mercury 2 passed within 22,000 miles (______________) of Venus. The 447-pound (________________) probe recorded Venus' surface temperature at 700 degrees F. (_____________________) and sent back valuable data on previously unexplored space.

9. The Gemini capsule is 10 feet (____________________) in diameter.

10. A total of 842 pounds (______________________) of lunar material was returned to earth by the Apollo astronauts.

11. The Skylab workshop weighed 199,750 pounds (____________________).

12. The shuttle's Remote Manipulator Arm is 55 feet (_______________) long.

13. Astronauts who are mission specialists must be between 60 and 76 inches (__________________________________) in height.

14. The Gemini-Titan rocket stood 108 feet (___________________) high.

15. Alan Shepard's suborbital mission lasted 15 minutes; his Freedom 7 spacecraft flew 116 miles (_____________________) high into space.

16. The Lunar Rover vehicle used on the last three Apollo missions was 10 feet (______________) long, and weighed 493 pounds (_________).

17. The maximum speed of the Lunar Rover was 10 MPH (_______________).

18. Surveyor 3 that landed on the moon was 10 feet (___________) tall.

19. The shuttle's external tank will hold up to 440,000 gallons (____________________) of propellant.

MATH READING PROBLEMS

Use the Human Spaceflight Log (pages 63-67) to help answer these math problems.

1. There were six Mercury flights. What was the total time spent in space by the astronauts on those flights? ____________________

2. Gemini 7 was the longest duration flight with a total of 330 hours 35 minutes 31 seconds. How many full days would this be? ________

3. How much more EVA time was used on Apollo 14 than Apollo 12?

   ____

4. Find the total number of pounds of rock samples returned to the earth by the Apollo missions. ______________________________

5. How many more pounds of rock samples were returned on Apollo 15 than on Apollo 11 and Apollo 14 combined? ____________________

6. What is the total number of lunar orbits completed by all of the Apollo astronauts that stayed in the command modules? __________

7. Find the total time astronauts have spent on the moon. __________

   ____

8. On Skylab 2, Astronauts Conrad, Weitz and Kerwin spent a total of 28 days aboard Skylab and completed 404 earth orbits. What is the average number of orbits each day? ________________________.

9. During the Apollo-Soyuz mission the Russian cosmonauts spent 142 hours, 31 minutes, 00 seconds in space. The American astronauts spent a total of 224 hours, 58 minutes, 33 seconds. How much more time did the astronauts spend in space than the cosmonauts?

____

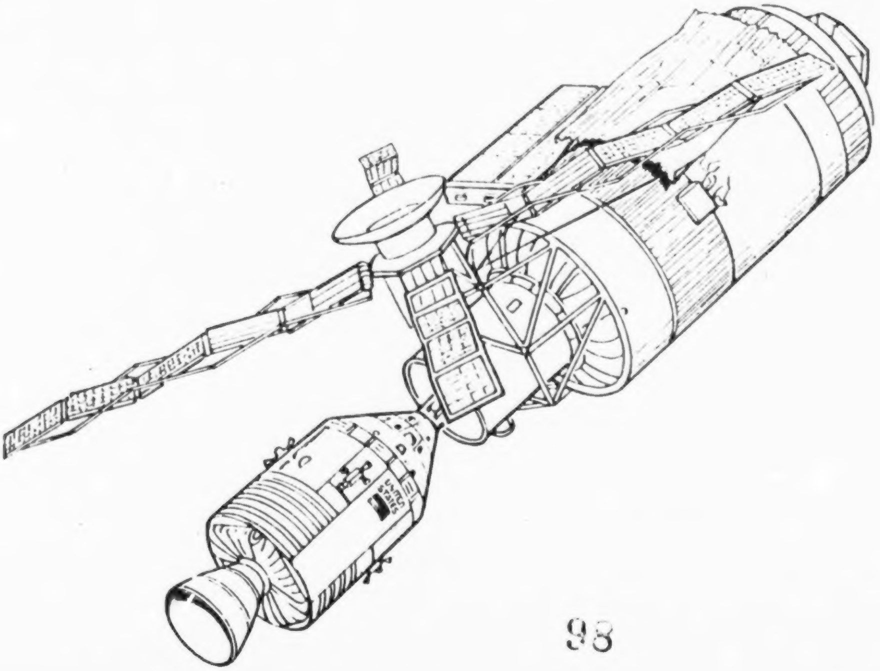
10. What is the total number of days spent in space by the first nine STS vehicles? ______________________________

11. Find the total number of orbits for the first nine STS vehicles.

____

12. When the Orbiter Columbia first arrived at Kennedy Space Center, it remained in the Orbiter Processing Facility building for 610 days. How many hours would that be? ____________________

How many weeks? ____________________________



WORK THE MATH PROBLEMS AND ANSWER THE QUESTION.

C	E	M	S	A	P	U	O	F	N	R	W
3	7	11	14	16	22	36	48	50	86	100	121

T	I	H
132	179	448

____	____	____		____	____	____		____	____	____
18 23 14 +66	32 x14	84 -36		11 x11	8)128	23.5 -9.5		22 x6	314 +134	6)42

____	____	____	____	____		____	____	____	____	____
14 16 +20	316 -137	10 x10	2)28	434 -302		224 x2	6 x6	4)44	8 x2	99 -13

____	____		____	____	____	____	____
96 +83	43 x2		7 x2	4)88	45 -29	6)18	8)56

ANSWER:____

Now make up your own question with the number code. Ask a friend to answer it.

MYSTERY PERSON

Work the problems to solve the mystery.

L	M	E	R	A	T	N	J	H	S	F	O	C	G	I	B	W
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

____ ____ ____ ____   ____ ____ ____ ____ ____

4)32 2)24 2)18 2)14   2)28 9)9 3)9 5)35 3)21

____ ____ ____   ____ ____ ____

2)34 5)25 2)20   6)36 4)36 5)15

____ ____ ____ ____ ____

2)22 2)30 4)16 4)40 9)54

____ ____ ____ ____ ____ ____ ____ ____   ____ ____

10)50 25)50 4)12 5)20 3)45 2)26 6)30 4)28   5)30 3)36

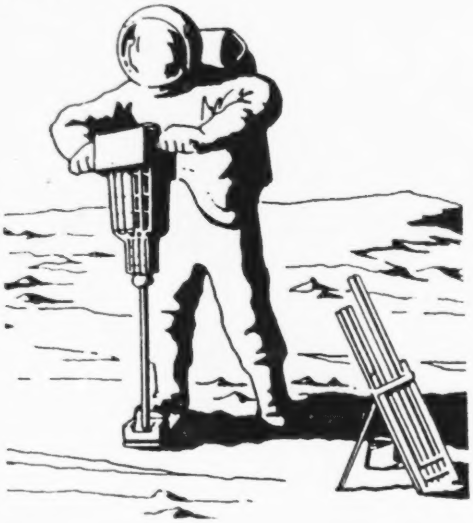
____ ____ ____ ____ ____   ____ ____ ____

4)48 8)32 2)32 4)60 7)42   8)48 9)81 9)27

____ ____ ____ ____ ____

7)21 9)45 7)28 11)66 7)63

UNSCRAMBLE THE WORDS



APOLLO
FUEL CELL
OXYGEN
ORBIT
PRESSURE
SATELLITES
MECO
COSMONAUT

AIRLOCK
PAYLOAD
RUNWAY
DEHYDRATION
SOYUZ
ASTRONAUT
MATE
SPACE STATION

1. KOCAIRL ______________________
2. YZOUS ______________________
3. NEDHYDRATIO ______________________
4. LLEUFELC ______________________
5. LPOALO ______________________
6. TOMCOUASN ______________________
7. TSNAARUOT ______________________
8. DYPAAOL ______________________
9. OCEM ______________________
10. AMET ______________________
11. ILTLESTESAT ______________________
12. XGOYNE ______________________
13. TIRBO ______________________
14. YAWUNR ______________________
15. RSSUPREE ______________________
16. TTSSNOIAAEPC ______________________

PRONUNCIATION SKILLS

Match the following words with their correct dictionary pronunciation.

1. ASTRONAUTS
2. LUNAR
3. REENTRY
4. GEMINI
5. MICROGRAVITY
6. ORBITER
7. SATELLITE
8. SPLASHDOWN
9. TREADMILL
10. SPACE SUIT
11. OXYGEN
12. COSMONAUT

_____ RĒ-'EN-TRĒ
_____ 'OR-BƎT-ƎR
_____ 'SPLASH-,DAU̇N
_____ 'LU-NƎR
_____ 'SAT-L-,ĪT
_____ 'TRED-,MIL
_____ 'AS-TRƎ-,NȮT
_____ 'KAZ-MƎ-,NȮT
_____ 'ÄK-SI-JƎN
_____ 'MI-KRŌ-'GRAV-ƎT-Ē
_____ 'SPĀ-,SUT
_____ 'JEM-Ǝ-NĪ

How many syllables are in each of the following words:

1. _____ fallout
2. _____ spacecraft
3. _____ orbit
4. _____ shuttle
5. _____ booster
6. _____ Spacelab
7. _____ revolution
8. _____ Apollo
9. _____ suborbital
10. _____ Enterprise
11. _____ countdown
12. _____ runway
13. _____ atmosphere
14. _____ airlock

COMPOSITION: WRITING A PARAGRAPH

Write a paragraph on one of the topics listed below. Be sure to follow the guides printed here for you.

HOW TO WRITE A PARAGRAPH

Have your topic clearly in mind.
Indent the first word of the paragraph.
Write a first sentence that will suggest the topic.
Make sure that every sentence keeps to the topic.
Make every sentence develop or tell more about the topic.
Begin and end each sentence correctly.
Include at least four sentences.

SUGGESTED TOPICS

1. Apollo Mission
2. Space Shuttle
3. Astronauts
4. Living in Space
5. Space Station
6. A space-related topic of your choice: ______________________________.

SPACE SPELLING

1. GEMINI
2. ABORT
3. SHUTTLE
4. AEROSPACE
5. MERCURY
6. BOOSTERS
7. ORBIT
8. COCKPIT
9. REENTRY
10. SPACELAB
11. APOLLO
12. SOYUZ
13. COSMONAUT
14. ASTRONAUT
15. SPACESUIT
16. DOCKING
17. ORBITER
18. CABIN
19. SKYLAB
20. RUNWAY
21. PAYLOAD
22. TELESCOPE
23. DEORBIT
24. GRAVITY
25. ROCKET
26. OXYGEN
27. WEIGHTLESSNESS
28. ARMSTRONG
29. GLENN
30. SHEPARD

Suggestions for spelling activities. Select one activity each day.

1. Divide words into syllables. Use the dictionary respelling and mark the vowels.

2. Put words into alphabetical order.

3. Look up the definition of each word and copy it on your paper. Now use the word in a sentence which uses that definition.

4. Create a wordsearch. Be neat! Someone else will be finding the words you hide in the puzzle.

5. Create a story using 10 or 15 of these words. Underline each word used. Have some of the words misspelled. Ask other students to to proofread the story. If an underlined word is misspelled, write it correctly. If the word is spelled correctly, make an asterisk (*).

SUBJECT AND VERB

Draw a line between the subject and the predicate. Draw one line under the simple subject. Draw two lines under the verb in the predicate.

Neil Armstrong landed on the moon July 20, 1969.

He said, "God's speed all the way, John Glenn".

Deployable, erectable, and manufactured are the three main kinds of large space structures.

Astronaut Edward White made the first space walk on Gemini 4.

Guion Bluford is the first American black astronaut to perform a spaceflight.

Skylab was occupied a total of 171 days.

On June 18, 1983, Sally Ride became the first American woman to fly in space.

The Apollo 13 mission was aborted after the service module ozygen tank ruptured.

Apollo 17 was the first night launch of American astronauts.

In July of 1975, a U. S. spacecraft docked with a Russian spacecraft in the ASTP program.

The Mercury program is the name of the one man space missions.

The Gemini 7 astronauts made the first docking of one space vehicle with another.

The USS Hornet served as the recovery ship for Apollo 12.

The astronauts on the Apollo-Soyuz mission made the last scheduled water landing.

"Houston, Tranquility Base here, the Eagle has landed."

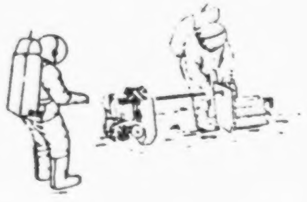
To remain seated on the shuttle toilet, the user must insert feet into foot restraints and snap together the seatbelt.

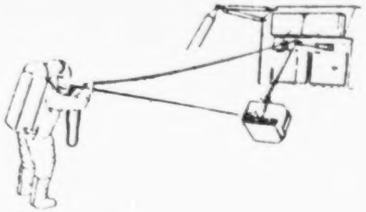
Around the year 2000, NASA plans to erect a lunar base on the moon.

SUBJECT AND PREDICATE

Write each subject below. Add a predicate to each subject and make a complete sentence. Use punction and capital letters correctly.

1. the first moon explorers
2. Russian Yuri Gagarin
3. spacelab
4. Apollo
5. Skylab
6. spacesuit
7. redstone
8. external tank
9. space station
10. lunar rover





1. ______________________________

____

2. ______________________________

____

3. ______________________________

____

4. ______________________________

____

5. ______________________________

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6. ______________________________

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7. ______________________________

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8. ______________________________

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9. ____

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10. ____

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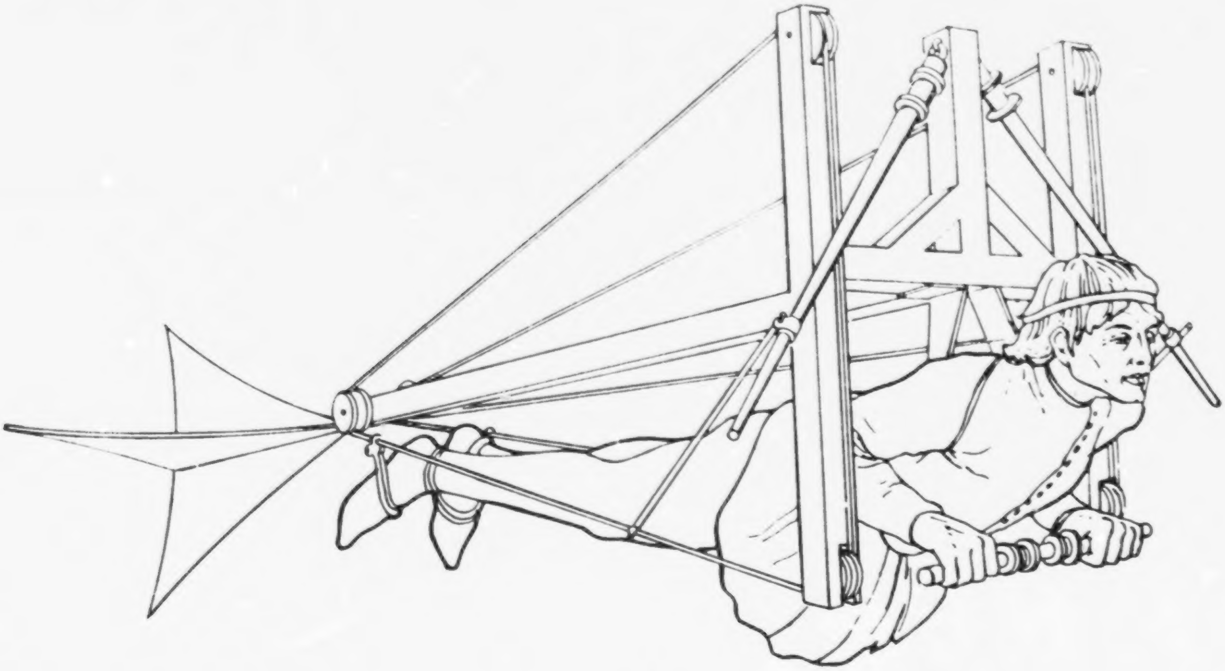
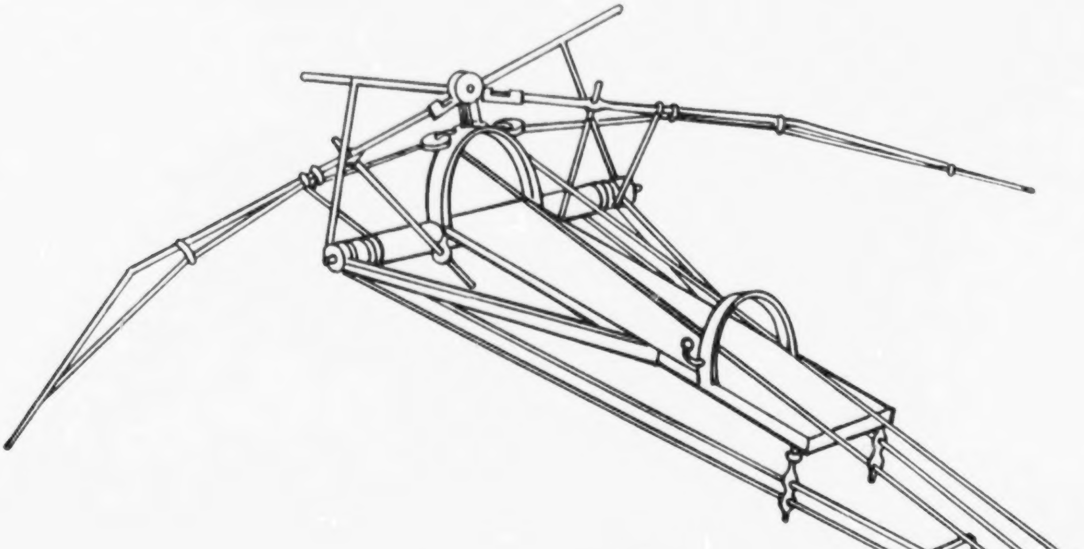
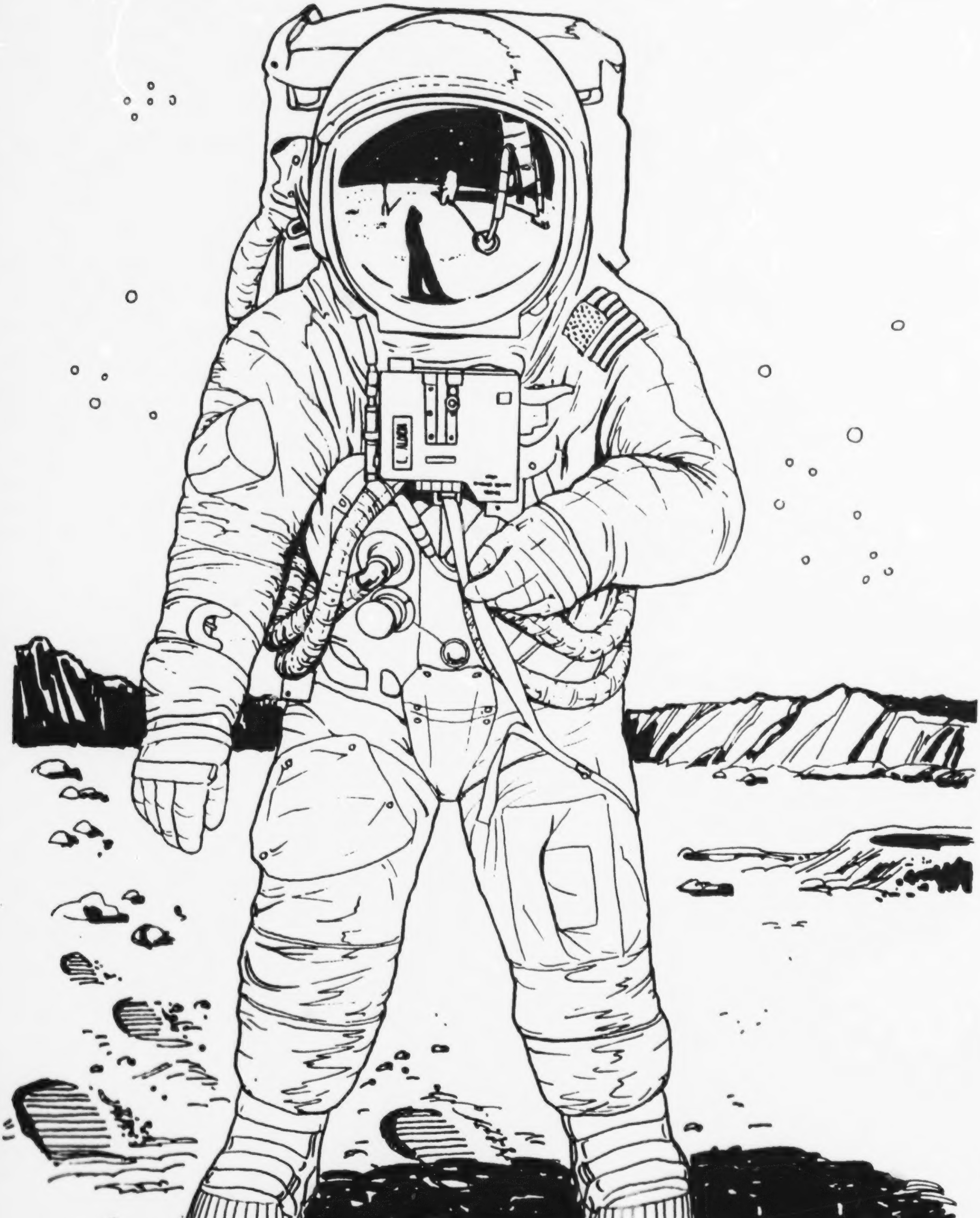






DICTIONARY SKILLS--1

From the list on the next page, find the word that goes best with the definition. Words should be used only once.

____________________ 1. A person who flies in space, whether as a crew member or a passenger.

____________________ 2. The first stage of a missile or rocket.

____________________ 3. A body of small mass but large volume compared to a planet, often developing a long, luminous and partly transparent tail when close to the sun.

____________________ 4. The Russian term for what in the U.S.A. is called an astronaut.

____________________ 5. The hours, minutes, and finally the seconds, of time remaining before the launch of a rocket.

____________________ 6. The technique of connecting two or more spacecraft in space.

____________________ 7. A device which protects people or equipment from high temperatures, in front of a reentry capsule as it reenters the earth's atmosphere.

____________________ 8. Of or pertaining to the moon.

____________________ 9. National Aeronautics and Space Administration.

____________________ 10. An orbit which passes over the north and south poles.

____________________ 11. Engines or devices fired to reduce the speed of a spacecraft.

____________________ 12. Useful cargo carried aboard a spaceship.

____________________ 13. America's reusable space ship.

14. The United States' first human space program

15. The act of going outside the spacecraft.

16. Name for the U. S. two-man space mission.

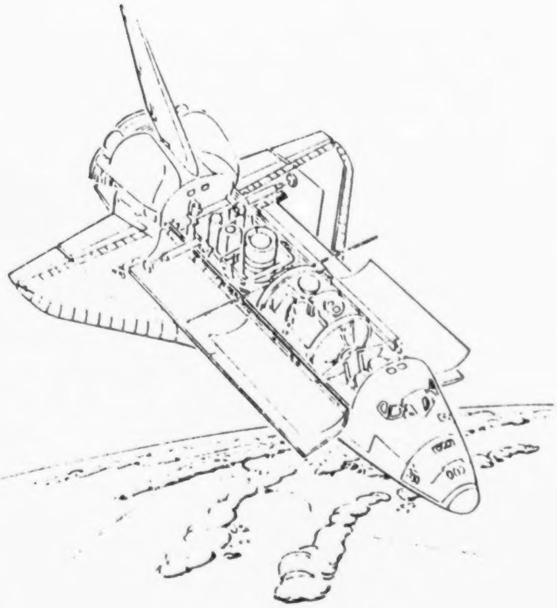
17. To come into or go out of orbit.

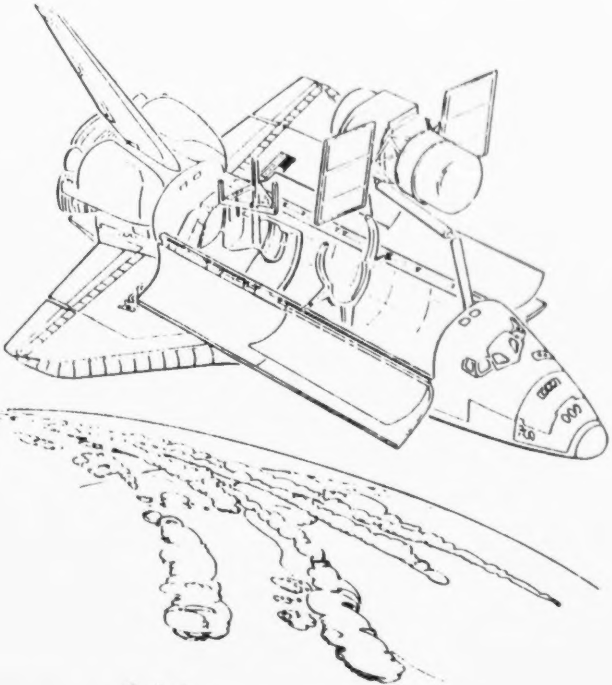
18. Joint United States and U. S. S. R. space mission launched in 1975.

19. Clothing worn by an astronauat for EVA.

20. Used as a life support system for extravehicular activity.

a) backpack
b) deorbit
c) Gemini
d) cosmonaut
e) Mercury
f) paylaod
g) shuttle
h) lunar
i) booster
j) comet
k) polar orbit
l) countdown
m) spacesuit
n) extra-vehicular
o) heat shield
p) astronaut
q) docking
r) ASTP
s) retro-rockets
t) NASA





DICTIONARY SKILLS--Part 2

Place the Space Vocabulary words listed below in the blanks shown between the correct dictionary guide words.

1. abort
2. yaw
3. telescope
4. deorbit
5. satellite
6. payload
7. Vostok
8. cockpit
9. runway
10. gravity
11. cosmonaut
12. spacesuit
13. rocket
14. astronaut
15. docking
16. boosters

1. dentil ______________________________ dependable
2. rumble-seat ______________________________ rupee
3. astragalus ______________________________ atavism
4. pawn ______________________________ peach
5. voluptuous ______________________________ vulcanite
6. cochlea ______________________________ codfish
7. satchel ______________________________ sauna
8. graupel ______________________________ grease
9. boogie-woogie ______________________________ borax
10. xylophone ______________________________ yearling.
11. docile ______________________________ dormitory
12. teleran ______________________________ tendon
13. Cosmoline ______________________________ cotter
14. rocker ______________________________ rogue
15. spa ______________________________ spar
16. ablaze ______________________________ absent

SAT

SHUTTLE AWARENESS TEST

The following quiz requires only one answer per question -- either true or false. The questions are designed to illustrate certain points about the space transport system know as the shuttle.

1. T F The shuttle will never fly to the moon.

2. T F The muffler for the launch of the shuttle is made of water.

3. T F You can breathe one of the two components used by the three main engines of the shuttle.

4. T F The robot arm of the shuttle can lift up to 32 tons in space but cannot lift itself on the ground.

5. T F The shuttle can carry up to seven people into space.

6. T F The toilet on the shuttle uses no water.

7. T F The cargobay of the shuttle is long enough to park a schoolbus and a family car.

8. T F The payload specialists who will go into space will not be trained as astronauts.

9. T F In orbit, the shuttle can go from one side of this country to the other in about twelve minutes.

10. T F The space shuttle could land at any major airport.

Bonus question: T F The drinking water for the crew is made while in space.

Answers: Number 1 is true. All the rest of the numbers (2 through 10) are true. The bonus question is the opposite of false!

LARGE SPACE STRUCTURE

NASA has asked Congress for funding to design, construct, and launch into earth orbit by the 1990s a large space structure (space station). You have been selected to work on one of the NASA decision-making teams. Your assignment and instructions are listed below. Congratulations and good luck on your appointment!

_____ 1. FUNCTION OF THE STATION.

Your duty is to decide what will be the function of this station in space. Should it be military or non-military? This and other questions will need to be answered.

_____ 2. NATIONALITY OF SPACE STRUCTURE INHABITANTS.

Should this station be operated solely by Americans or should this be an international work station? Your decision must be supported by statements explaining why.

_____ 3. STAFFING OF THE LARGE SPACE STRUCTURE.

Your task is to select a group of people to operate the space structure and to explain why these people were selected. A list of possible of candidates will be provided. (Following page)

_____ 4. DESIGN, CONSTRUCT AND PLACE YOUR STURCTURE IN SPACE.

You report should include a drawing and description of the structure shape; a listing of materials used in construction; a step by step report on how the structure will be placed in space and where it should be placed. Any other pertinent data to successfully complete your part of the task should also be included.

_____ 5. (Optional) Build a model of the structure.

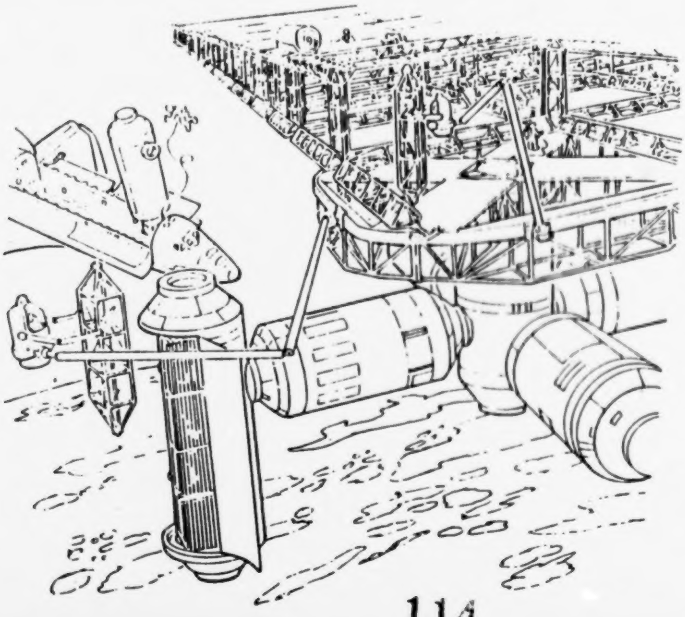
POTENTIAL PERSONNEL FOR SPACE STRUCTURE

1. Medical doctor
2. Nurse
3. Lawyer
4. Teacher
5. Cook
6. Military person
7. News media representative
8. Librarian
9. Policeman
10. Computer expert
11. Communication expert
12. Minister
13. Politician
14. Astronaut
15. Janitor
16. Administrator
17. Fireman
18. Psychiatrist
19. Pharmacist
20. Aeronautical engineer
21. Mechanical engineer
22. Astronomer
23. Geologist
24. Meteorologist
25. Rocket expert
26. Mathematician
27. Entertainment director
28. Historian
29. Mechanic
30. Others (be specific)

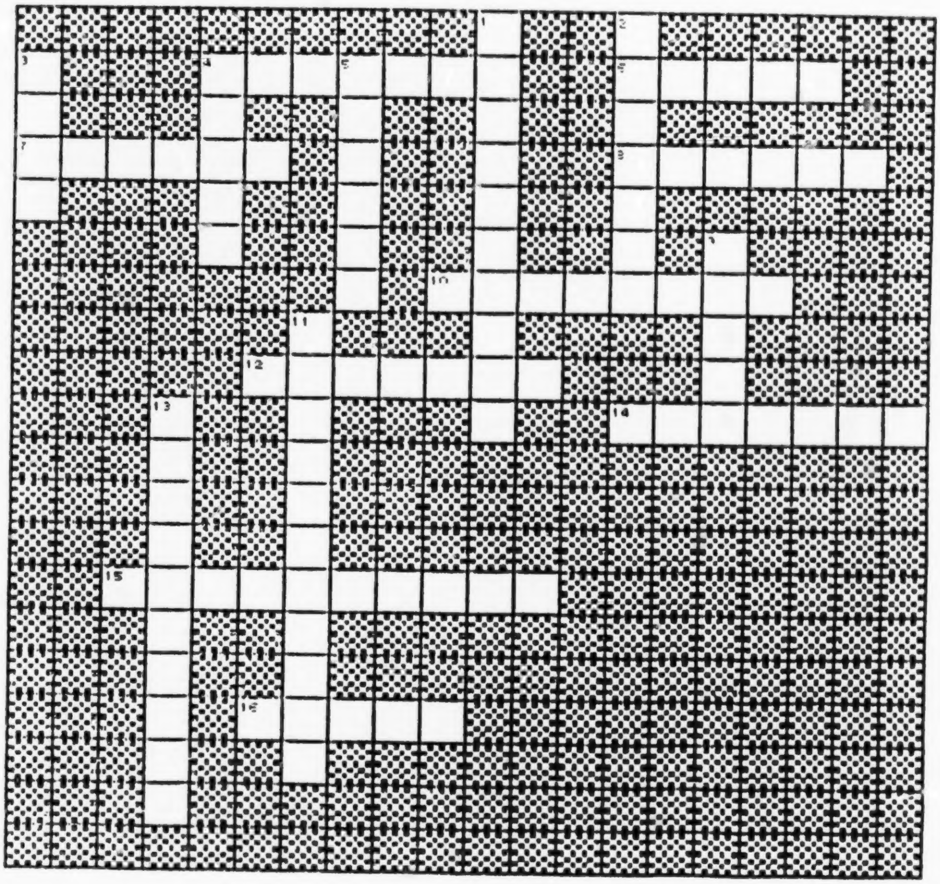
NOTICE!!!

Because of budgetary cut-backs, the funds for personnel hiring have been drastically cut. You will be able to select only ten people to staff the station in the beginning. List them, giving reasons for their selection. Each person would be expected to stay on the station for at least six months.

If funds become available, some of you will be able to select five more individuals. Those decisions will depend on the reasons you state for the five additional staff you decide to take if possible. Be sure that your statements are convincing!



FANTASY OF FLIGHT



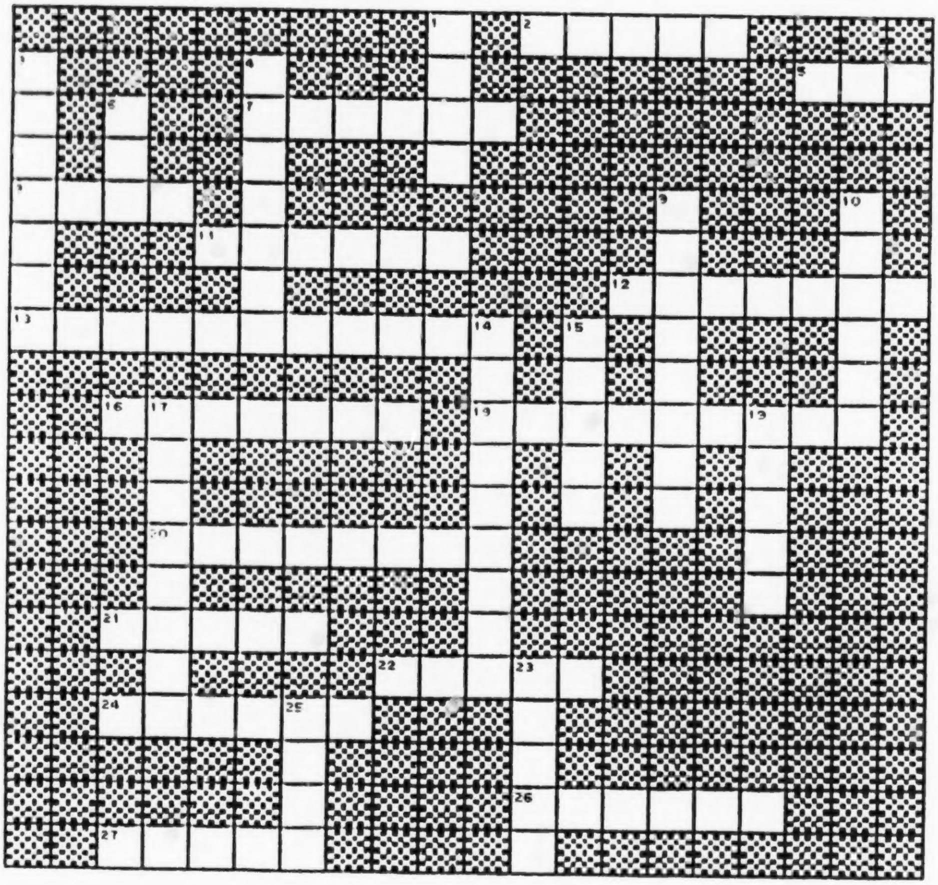
ACROSS

4. Man who invented the telescope
6. King Etena is said to have flown to heaven on the back of it
7. In Cyrano book "Voyages to the Moon and the Sun" a machine powered by a ______ was used
8. Man who attempted lunar flight by using bottles filled with dew
10. The Egyptians called it the "Heavenly Nile"
12. Great science-fiction classic of spaceflight published in 1634
14. Persian mythical king was carried into the clouds on his throne by 4 eagles
15. With their arithmetic they acquired knowledge about the periods of the sun, moon, and planets
16. Over 1500 years before Christ, the Egyptians recorded seeing this planet

DOWN

1. Polish astronomer who stated that the earth orbited around the sun
2. Winged messenger of the gods
3. Novel,"Across the Zodiac", hero traveled to this planet
4. Domingo Gonsales was carried to the moon by their migration flight
5. Daedalius' son who flew too near the sun
9. He proposed a lighter-than-air ship in 1670
11. Frenchmen with first successful balloon flight June 5, 1783
13. His followers first suggested that the earth was round or a sphere

SPACEFLIGHT - THE EARLY YEARS



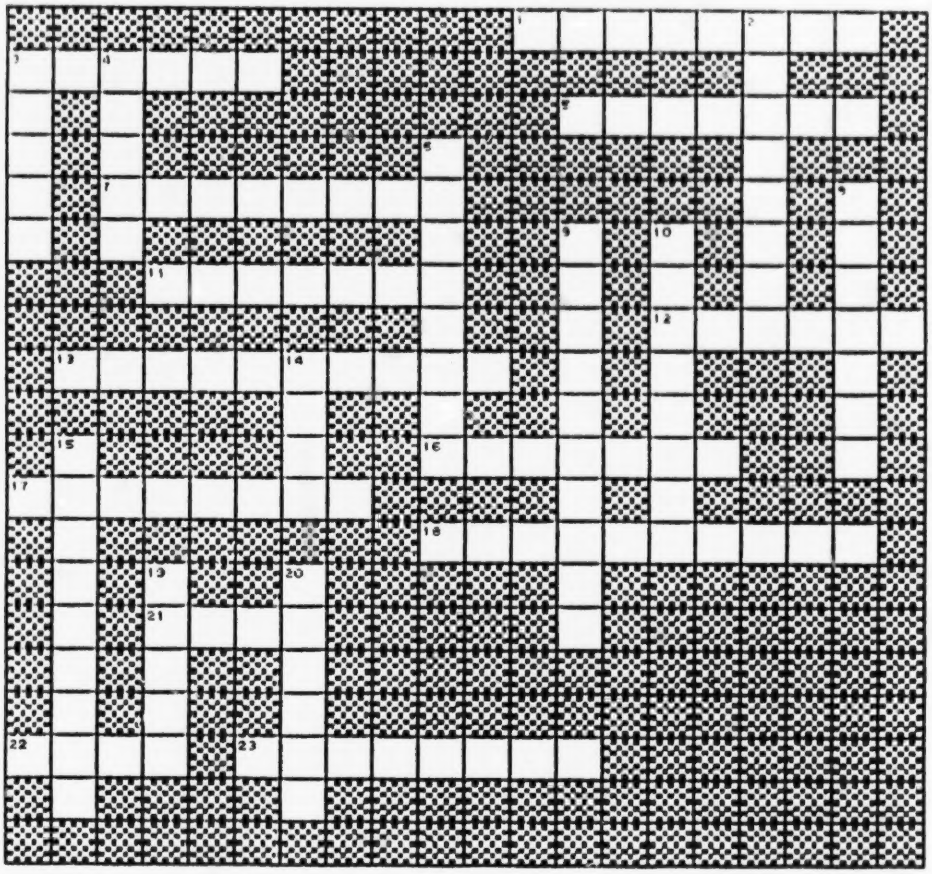
ACROSS

2. Number of men on an Apollo mission
5. Number of astronauts on Gemini mission
7. Recovery ship for Apollo 12
8. Apollo missions traveled to the ____
11. Rocket used in the Apollo mission
12. Command module for Apollo 9
13. Recovery ship for Apollo 17
16. Astronaut who flew Mercury 4 mission
18. Astronaut on Apollo 16
20. Apollo 12 returned part of _______ 3
21. Astronaut who flew first 2 man mission
22. Name of Apollo 11 lunar module
24. Name of 2 man space mission
26. Name of 3 man mission to the moon
27. First American to walk in space

DOWN

1. Kind of cells used for power on Mercury 5
3. Last American to walk on the moon
4. First American in space
6. Number of astronauts on Gemini mission
9. Lunar module for Apollo 13
10. Lunar module spacecraft on Apollo 10
14. First man on the moon
15. Rocket used in the Gemini program
17. Rocket used in Mercury 4 mission
19. First American to orbit the earth
23. Spacecraft name used to land on the moon
25. Number for the last Mercury mission

SPACEFLIGHT - THE LATER YEARS



ACROSS

1. Name of first orbiter to fly
3. American space station launched in 1973
5. European specialist on STS-9
7. Strip where STS-3 landed
11. Ocean where Skylab 4 crew landed
12. Country American craft docked with
13. Pilot on STS-4
16. First American black astronaut to fly
17. Comet observed by Skylab 3 crew
18. Shuttle orbiter that never flew in space
21. First American woman in space
22. Month ASTP mission was launched
23. Shuttle uses 2 solid fuel ______

DOWN

2. Shuttle uses 2 solid fuel ______
3. Name of a Russian spacecraft
4. Commander of first shuttle flight
6. Primary payload for STS-9
8. Ocean where Skylab 4 crew landed
9. Pilot on STS-4
10. Strip where STS-3 landed
14. Total rocket engines for shuttle liftoff
15. Name for Russian space traveler
19. Pilot of STS-2
20. Russian cosmonaut on ASTP

HUMAN SPACEFLIGHT

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O G D I F D C X A A G A R R I U T T X O J V X C X I D Y
U L B S M M W R Q D K O L F A L C O N Q O P E X W K T B
V V K P J E P M O S S I R G P P H H P C B J I N V I A L
J K C A I Q J H O R N E T G I Y H V Y E P C N B L L T R
Q P I C X P G B A A M V N P O G U E A V I A I I Y R A U
T H F E F X Y S H E P A R D A M U N A J X N U K X Q B V
C M N Y X K T B V T S Y B X J S Y Y V K B Q S G E R V O
M U T F T R K W C F A T O C H T T Y E R N Q K L P S L J
C A I M O M E N Q C A G O P D B T T I A E U M G L F S U
X J A N U I E B S H U T T L E W U T R X K E X Q V U J K
Q O A Q T Y F F S P E L O J F O I T O C W C D G C U M V
A U M Z E X N A V D A E O S H K M N A I S S U R M G F I
T R L I B I F Y K S I S X O H Y M L W G B E S O Y U Z N
J A Q X W M T F B R L C K L H T U A N O M S O C T R O P
N D R R U A T H F J E E R S D M P D V R L M O R T T L S
R V E K C F N H P C P W R Y U F R L K G K P D D Y N N E
S K E N A C K Y L E O N O V Q O E V J Q I W O A V O E N
S I C H R T G L E N N Q L V F D N A R B N L L G T S J J
Y R U C R E M J A W Q T E F T F Y V G R L S O U D B F W
A B N K T Y C T P G W J A G A X S L O O E X U H A I X W
C T S Q U H I A R M S T R O N G Y G P S B P I Y R G A U
P M E P S T L O Y O S F O L P J V A G V A I S A N C L J
X G T I C O N D E R O G A B V A X K T D O B E A O Y D H
T I B R O M R K D R R X K A O I P G Q I O L U R C B R Y
B U O X R M W O M W O Q Y U D G D P U F T P W K A Y I M
R S V N L K S A T U R N O H V A G E M I N I A P R L N E
Q D H M V M O C F A D A T S R N U S C Q M B T S C R Q I
K I Q Y J Y L O U S M A M S P B J L C C O M E T I O A C
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SKYLAB
KERWIN
CARR
COMET
APOLLO
SLAYTON
LEONOV
SHEPARD
ASTRONAUT
TRANQUILITY
TICONDEROGA
BEAN
POGUE
KOHOUTEK
SOYUZ
ORBIT
KUBASOV
GRISSOM
ARMSTRONG
ALDRIN
CONRAD
LOUSMA
GIBSON
HORNET
STAFFORD
SATURN
COSMONAUT
GEMINI
CASPER
SHUTTLE
WEITZ
GARRIOTT
SPACE
SUN
BRAND
RUSSIAN
GLENN
MERCURY
FALCON
TITAN

SKYLAB

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G O Q D H G E M Y A I N I C A K K K O H F I N U K U S T T B W T
W I B C D T D U N U T E L E S C O P E E A K R N U D D N N J Q R
G G Q A O E U G O P H L Q W T T F I P W P Y U F J P D N O L Q J
I G M G T T L F N W F T J K A X V H J F G P M W H S I M H T D T
B A O B J S E K T Q A Q T V V H Q D O C E A N O G R A P H Y D V
S P Y X E P E D R H J C H W C Q D W U O M Q I L I H P E W A H U
U J R Q J R J G P A Q J I O Q W G Y H T U A N O R T S A W P C A
N K H X W D K C Y Q C O N R A D N F C Y F C X V W P I H C X N G
I J E I P F D I Q W T A R I A U L R H P S V R A L O S N R H U R
S S N D M Q F R J K X H J R C M Q J Y Q A Y H R G N S I E X A U
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I Y X C O A X X P R E E O T R B Q N U H F B P V K M D B T X R W
V V R G W F T Y L B N B Q R M N Y M R G F I J A S N A R A L R M
X D N P T E Y X L W O L S C A E P J E Q G F F V O L T Y A R A W
N Y P J P W V W K F A X Q L M L M O U J G S H M D T U C A I N X
Q K E G N U K U Y U R R W V T M G I T O Q K D T O W I X Q M E Q
Q L X F W D O R T M E W U I N R G N R F K W J I V M G E B N N K
U U F H M J H K R Y W D A Y A X F H N E E K R K E H F T G I K V
X U R V U W O S M T Y E X P N D I B I P P R R H S I T I V E I T
M R C R Y H U H H M R A H O M V H S T M A X C F V U E X Q Y B A
E G L R A L T O F U I Y Z T I E W G Q G P O E Q P Y R S O C I C
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S O D J O Y H C T T F C K I E F D D T S A T U R N J X F R G F O
X U F W B T A S F O X Q W Q O Q E W U H O Y Y K T N O I Y L D M
O M J W S P E R X L Y K A J P N Q D W H B E H S M U S D A O U E
P I Y A S R K X K I E C O L O G Y U U I W Q Q X J F S T O U J T
W N L B O B U K B S K Y L A B Y E J U R Y X T V H K H Y K X M K
Q S N F G J I F C U P J W J A D F X V H R X W D J O B A W N M X
H V G O M X F V N U S N W O D H S A L P S U M F H I Q R M W T C
K J C U W X X Q Q Q N Y G H P P T E R U T L U C I R G A Q T D S
V H C A N N S U M H K B E A N S R M L H G J L O U S M A V L Q V
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SKYLAB
POGUE
SUN
BIOCHEMICAL
KERWIN
KOHOUTEK
ASTRONAUT
GEOGRAPHY
GARRIOTT
TELESCOPE

SPACE
CONRAD
GIBSON
AGRICULTURE
OCEANOGRAPHY
BEAN
WORKSHOP
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CARR

EXPERIMENTS
SATURN
WEITZ
COMET
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MISSION
ECOLOGY
SPLASHDOWN

SPACE SHUTTLE

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M W T N U F U F Y X N T C N L L A P T M Q X G Q U V E Q
E V K Y G U H A T W L V W E L A I B M U L O C D M N L T
V A C E T J C K W I R O Y H A U C K R F Y L M Q C O A P
A A H L G W H J W B D T Z D G M S K H J R E H S T M H K
R H A Y A A Q L Q H V T A V H B L U F O R D T D C O U V
G U L N R R I J C T I O C S H D M R X P J E T V P V W X
S F L N D U H U I E L   O K B O B K W G T M L S T J O K
U I E U N E O F W Y X H I L F M C F I V T E H G E M D F
M C N V E T F T A U L U U P Y P J J I U O D P I N W X X
D T G M R Y R P C H P I T O T K J E B X I G S G M E G G
S H E A M S U O L S K V P B I C P L Q H R G U W M M B J
W M R K M D I A K K L U E A V U A I A D R Y N E R Y C I
C G J E E G M B A M G N T P A K R T Q C A G T U M F R L
C U Q T M K R P L H E C E A R A K N G V G I A T O I N S
E R D S H A W K L L D P R F G I E R O N L O G J Q Y I C
Q M I D D E C K E A K Q S D O O R O I L K H H M T P E L
S X U O X X S G N Q G T O S R D C S E J O X U R F S T N
H X D W A C K N O A V A N H C E Q T U E N A I E E P S O
N E P P I R C Q I N S A R U I Y A U T A A M C R D E N T
U D V J K E E N R T T O O T M S E Q Q N I A K R R C E R
I R N E A E D I R L Y I V T X B D O O U B T V J A I D E
K Y T P J N E U U R G L N L U D N H F S A T R E G A N L
F S C P T N N S F X L T L E U U A S R D F I L A A L A L
A T R L T A D S P A C E L A B A R P J L Y N Q L H I R U
Y I M A U H A R T S F I E L D G B V B Q W G E L T S B F
D B I T K X N C I T H O R N T O N S I R M L A E X T W B
U G R E B N E T H C I L G O M M I G K N G Y U N R S R P
C D W S L W U V E R M Y E R W W F P M E R B O L D J R R
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SHUTTLE
SPACELAB
CRIPPEN
LOUSMA
TOUCHDOWN
HARTSFIELD
SATELLITE
CHALLENGER
OVERMYER
LENOIR
WEITZ
PETERSON
ASTRONAUT
HAUCK

RIDE
BRANDENSTEIN
BLUFORD
SPECIALIST
MERBOLD
GARRIOTT
COLUMBIA
YOUNG
ENGLE
FULLERTON
TILE
MATTINGLY
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BRAND

ALLEN
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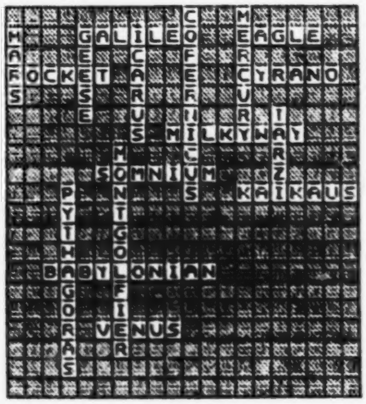
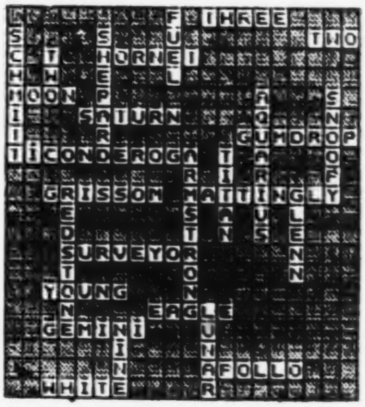
WORD PUZZLE ANSWERS

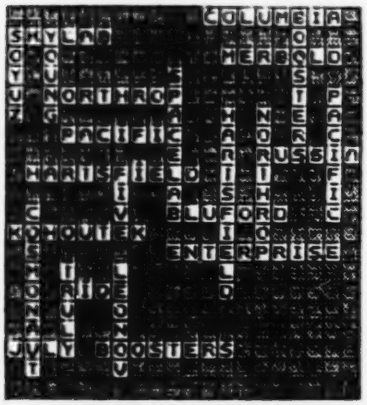
Fantasy of Flight



Spaceflight-the Early Years



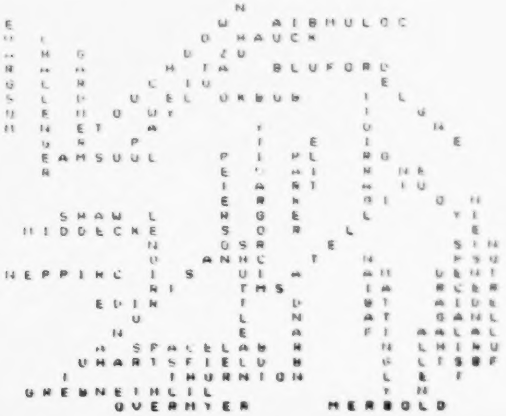
Spaceflight-the Later Years

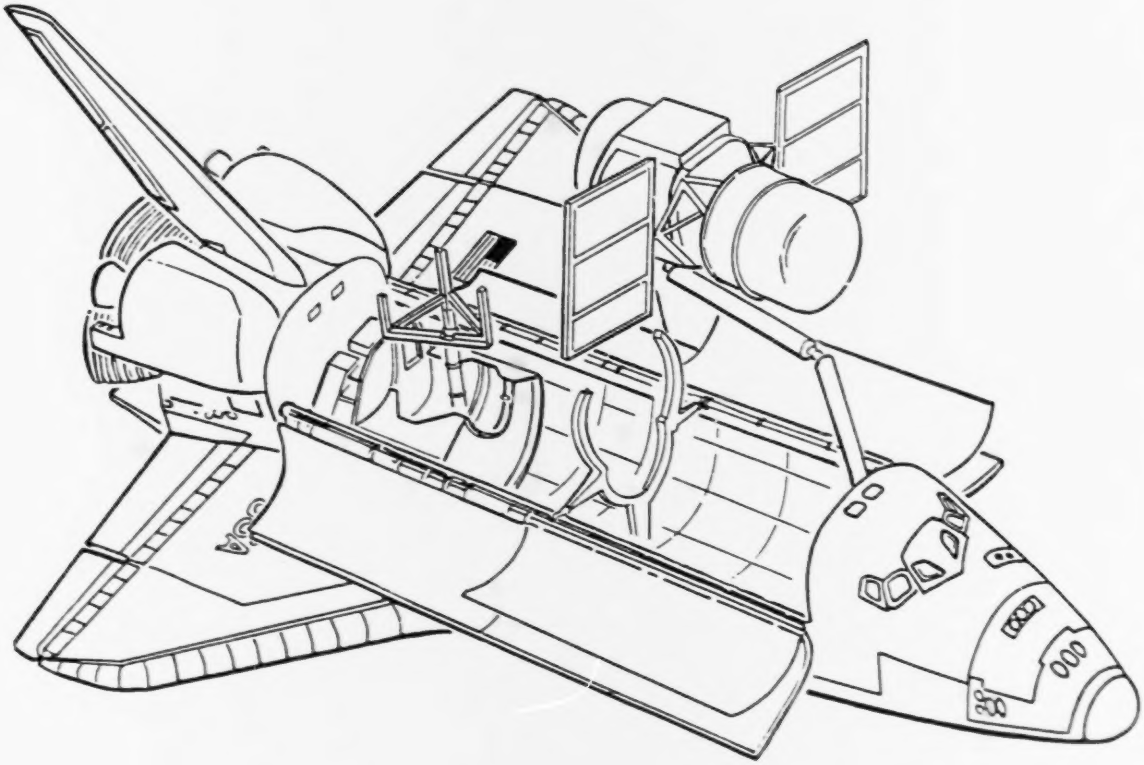


Human Spaceflight

Skylab

Space Shuttle





"The greatest gain from space travel consists in the extension of our knowledge. In a hundred years this newly won knowledge will pay huge and unexpected dividends."

Professor Wernher von Braun

"Science-fiction yesterday, fact today—obsolete tomorrow."

Otto O. Binder, Editor in Chief, *Space World Magazine*

"It is difficult to say what is impossible, for the dream of yesterday is the hope of today and the reality of tomorrow."

Robert H. Goddard in his high school oration (1904)

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"First I believe that this Nation should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to Earth."

President John F. Kennedy, Special Message to Congress, May 24, 1961

"If we die, we want people to accept it. We are in a risky business, and we hope that if anything happens to us it will not delay the program. The conquest of space is worth the risk of life."

Astronaut Virgil I. Grissom

(On January 27, 1967, Astronauts Grissom, White, and Chaffee died from a flash fire aboard Apollo 204 Spacecraft.)

"Some day people will travel to Mars. It will be a long trip, but fun. This will be a big step for mankind. We would be able to find out if there was life on this planet. It probably will look like a red desert."

J. Stephen Hartsfield,
Seventh Grader, 1984